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NITROGEN STATUS OF GRAPE-VINES AS REFLECTED BY THE ARGININE CONTENT OF THE FRUIT

By

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Changes in the free amino acid composition, particularly the arginine content, in the fruit of four wine-grape varieties (Rizlingszilváni, Ezerjó. Hárslevelű and Olaszrizling) during ripening in response to nitrogen fertilization were studied. Must preserved with merthiolate was used for the analyses after adequate purification and concentration) procedures. The quantity of free amino acids was determined using an automatic amino acid analyser. On the basis of results obtained over three years (1976, 1977, 1978) it can be established that of all the free amino acids it is arginine that accumulates in the largest quantities during ripening (correlation coefficient $r = 0.950$). In 1976 and 1977, when the ecological conditions were more favourable, the effect of nitrogen was better felt than in the cooler and rainier year of 1978. In the fruit of the variety Rizlingszilváni the nitrogen application resulted in a relatively high rate of arginine accumulation. Considering the fact that the quantity of arginine increases considerably in the fruit of grape-vines better supplied with nitrogen, the arginine content could be very useful as an indicator of the nitrogen status of the vine.

Introduction

Among the major mineral elements, nitrogen plays the most important role in the metabolic processes of plants; in particular, its incorporation into proteins and nucleic acids is of primary importance from the point of view of plant life. An adequate supply of nitrogen results in intensive vegetative development. At the same time the unfavourable effects of nitrogen must also be taken into account; namely, higher rates of nitrogen application prolong the growth period and delay the ripening of the fruit. Disturbances in the nitrogen supply, nitrogen deficiency in particular, often fail to be noticed in the vine until they are at an advanced stage, in which case intervention fails to produce the expected result.

It thus proved necessary to elaborate a rapid, precise standard method to indicate the nutrient deficiencies of the grape-vine in good time.

Leaf analysis is a suitable method for determining the nutrient status of the soil and the plant, and the effect of fertilization (GRIEGEL 1968, LÉVY—CHALER 1972, KOZMA—POLYÁK 1972). After statistically processing the information obtained in the course of the experiments it can be established that the average NPK and Mg contents of leaves originating from different vine regions very considerably, and the differences reflect the effects of climatic, cultivation and economic factors.

KOZMA—POLYÁK (1973) studied the effects of 18 quantitative combinations of NPK on the productivity of vine and the chemical composition of leaf in the variety Olaszrizling using a culture pot system (KOZMA—POLYÁK 1968).

On the basis of leaf analysis it was found that a rise in the N, P and K levels of the soil increased the N, P and K contents of the leaves, while at certain P and K levels of the soil the nitrogen content in the leaves rose in response to increasing rates of N application.

However, for a large number of samples the total nitrogen determination is a relatively slow and time-consuming procedure. The determination of the nitrate nitrogen content of the vine petiole — also suggested for use as an indicator of the nitrogen status of vine (COOK 1961) — has similar limiting factors.

A number of authors have studied the effect of nitrogen fertilization on the free amino acid content in various organs of the grape-vine (STOEV *et al.* 1966, DITTRICH *et al.* 1970, KLIEWER—COOK 1971, DORER—MALNARIC 1978). The authors give contradictory opinions on whether an unambiguous correlation exists between the nitrogen level of the soil and the free amino acid content of the grapes.

The present paper aimed to examine under field conditions, and as a function of the course of ripening, whether changes in the nitrogen supply of the vine were reflected by the free amino acid and arginine contents of the fruit.

Material and method

The varieties *Vitis vinifera* L. cv. Rizlingszilváni, cv. Ezerjó, cv. Hárslevelű and cv. Olasz rizling were chosen for the experiments.

Before the plantation of the vine cultivars (at Szigetcsép in 1966) 600 kg K_2O, 200 kg P_2O_5 and 100 kg N/ha were added to the sandy soil which was poor in humus. For Rizlingszilváni the experiment was carried out in a 5×200 m² plot and from 1973 onwards the vines were supplied with additional potassium (200 g K_2O/m^2) and nitrogen (100 g N/m^2) (POLYÁK 1974).

From the vines of untreated and treated cultivars samples were taken every two weeks from the middle of July until the vintage for a period of three years (1976—1978). The culsters of grapes were washed with running water, then dried between layers of blotting paper. The juice was pressed out of the grapes using a fruit centrifuge and, after settling, was centrifuged for 10 minutes at 8000 rpm for further purification. The must samples were preserved with merthiolate applied at a concentration of 0.005% and were stored in air-tight 1-litre bottles at 0 °C until the chemical analysis began.

1. The total nitrogen content of the must samples was determined by Kjeldahl's method (BAILEY 1967).

2. Prior to the free amino acid analysis the proteins were removed from the samples by alcohol precipitation (KLIEWER 1968) and ultrafiltration (MOLNÁR 1972). Free amino acids from the samples were identified on a Fixion 50×8 layer containing cation exchange resin (DÉVÉNYI—ZOLTÁN 1970) according to the method of DÉVÉNYI *et al.* (1971). The chromatograms were evaluated by video-densitometry (DÉVÉNYI 1976). The quantitative evaluation of free amino acids was carried out with an automatic amino acid analyser.

The analyses were performed in three replications and evaluated statistically.

Results

1. Changes in the total nitrogen content

Changes in the total quantity of nitrogen during maturation showed nearly the same trend in all three years and in each variety examined. Rizlingszilváni contained the largest and Olasz rizling and Hárslevelű the smallest quantities of total nitrogen (37—47 mg/100 ml and 27—33 mg/100 ml, respectively) of all the vine varieties examined.

In the growth period of the green fruit the nitrogen content of the grape juice increased, reaching a concentration of 44.95 mg/100 ml in 1976, 48.03 mg/100 ml in 1977 and 41.63 mg/100 ml in 1978 when averaged over the varieties. On colouring the grapes lost some of their total nitrogen content, which then either rose again or did not substantially change until the completion of ripening.

This fluctuating change in the total amount of nitrogen is caused by the increase or decrease in inorganic (ammonia, ammonium, nitrate) and organic (amino acids, peptides) nitrogen compounds translocated into the green fruit during maturation.

With regard to the effect of nitrogen fertilizer, there was no great difference in the total nitrogen content of the must of untreated and treated

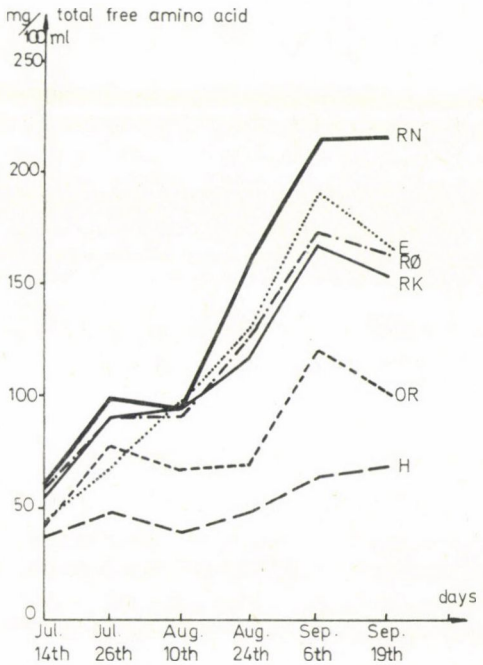

Fig. 1. Changes in the total free amino acid content of must samples in various untreated and treated vine varieties during maturation (1977)

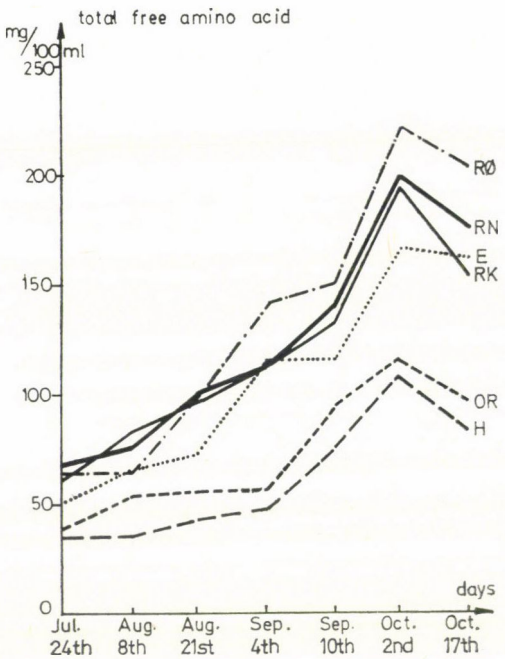

Fig. 2. Changes in the total free amino acid content of must samples in various untreated and treated vine varieties during maturation (1978)

varieties in 1976 and 1978. The effect of nitrogen fertilization was more obvious in 1977. On the average of the last two occasions of sampling the must of untreated Rizlingszilváni contained 35.66 mg/100 ml nitrogen, while that of nitrogen-treated Rizlingszilváni contained 41.00 mg/100 ml nitrogen.

2. Changes in the total free amino acid content

a) *Changes in the total free amino acid content during maturation.* The total free amino acid content of the must shows very great varietal differences.

Among the varieties examined Rizlingszilváni had the highest and Hárslevelű the lowest free amino acid content in the must (Figs 1, 2).

The total free amino acid content of the must in the last samples taken at vintage time reached a concentration of 192.8 mg/100 ml for Rizlingszilváni, 153.3 mg/100 ml for Ezerjó, 107.2 mg/100 ml for Olasz rizling and 90.7 mg/100 ml for Hárslevelű over a three-year average, according to the evaluation made with an automatic amino acid analyser.

The free amino acid content of the must increased during maturation. The correlations were found to be significant in all three years at a significance level of $P < 1\%$ ($r = 0.93$).

b) *Changes in the total free amino acid content in response to nitrogen treatment.* On studying the effect of nutrition on the composition of total free amino acids in the must, taking the data of all three years into consideration, the following facts could be established: as a response to nitrogen application the total free amino acid content of the must from the variety Rizlingszilváni increased considerably in 1976 and 1977, and decreased in 1978 compared to the control (Tables 1—5). When the last samples were taken at vintage time in 1976 the concentration of total free amino acids was 217.5 mg/100 ml in the must of N-treated Rizlingszilváni, 207.2 mg/100 ml in the control, and 179.0 mg/100 ml in the must of K-treated Rizlingszilváni (Table 1).

Table 1

Free amino acid composition in the must of untreated and treated grape varieties harvested on 21st September 1976 (mg/100 ml)

Amino acid	R∅	RN	RK	E	H	OR
1. Asparagic acid	9.32	6.83	3.42	5.79	2.92	3.27
2. Threonine	20.80	17.08	8.35	8.73	19.88	9.80
3. Serine	21.71	19.47	17.70	9.98		15.50
4. Glutamic acid	18.36	16.60	15.66	15.54	10.92	14.44
5. Proline	16.38	18.00	17.13	14.50	8.73	+
6. Glycine	+	0.86	+	+	+	+
7. α-Alanine	16.90	17.80	6.61	14.80	9.80	9.90
8. Cisteine	+	+	+	+	9.27	+
9. Valine	4.26	2.54	1.91	4.28	2.18	+
10. Methionine	+	+	+	+	+	+
11. Isoleucine	3.30	2.42	1.41	0.78	0.71	1.61
12. Leucine	5.14	3.57	1.94	1.59	1.42	2.34
13. Tyrosine	1.52	1.15	+	+	+	0.78
14. Phonylalanine	3.47	3.32	2.13	1.44	1.35	2.33
15. Histidine	7.07	9.96	9.02	4.80	6.56	3.93
16. γ-Amino butyric acid	10.29	13.20	15.24	15.18	13.46	17.32
17. Lysine	+	+	+	+	+	+
18. Arginine	68.70	84.74	78.48	30.83	29.73	39.64
19. Ornithine	+	+	+	+	+	+
20. β-Alanine	+	+	+	+	+	+
21. α-Amino butyric acid					+	+
22. Tryptophane	+	+	+	+	+	+
23. Hydroxy-proline						
Total:	207.22	217.54	179.00	128.24	116.93	120.86

Table 2

Changes in the free amino acid composition (mg/100 ml) in control Rizlingszilváni (R∅) grapes during maturation (1977)

Amino acid	Date of sampling					
	July 14th	July 26th	August 10th	August 21st	Sept. 6th	Sept. 19th
1. Asparagic acid	2.07	2.90	2.34	3.00	3.46	3.39
2. Threonine	10.30	18.90	20.86	7.17	14.20	11.62
3. Serine				17.22	0.06	0.24
4. Glutamic acid	12.00	12.50	6.52	7.30	10.17	16.01
5. Proline	+	2.60	4.32	9.88	27.44	25.48
6. Glycine	+	0.39	+	+	+	+
7. α-Alanine	3.00	2.60	4.38	6.55	15.46	7.63
8. Cysteine	—	—	—	—	—	—
9. Valine	1.30	2.81	0.47	0.81	1.27	1.43
10. Methionine	0.65	0.37	0.36	+	0.58	+
11. Isoleucine	0.43	0.54	0.69	0.42	0.61	0.76
12. Leucine	8.40	0.50	0.94	0.70	1.08	1.21
13. Tyrosine	+	0.39	0.72	0.51	0.84	1.13
14. Phenylalanine	1.06	1.11	1.01	1.05	1.51	2.11
15. Histidine	1.62	1.05	2.04	2.16	3.17	2.05
16. γ-Amino butyric acid	1.18	0.65	1.20	1.57	2.27	4.34
17. Lysine	+	0.85	+	+	+	+
18. Arginine	22.57	42.20	44.60	69.00	82.65	79.51
19. Ornithine	0.50	0.61	0.64	0.77	0.30	0.42
20. β-Alanine	+	+	—	—	+	+
21. α-Amino butyric acid	—	—	—	—	+	+
22. Tryptophane	+	+	+	+	1.50	0.67
23. Hydroxyproline	+	+	+	+	+	+
Total:	57.08	90.97	91.09	128.11	174.57	164.00

In 1977 the concentrations of total free amino acids were 216, 164 and 153 mg/100 ml in the musts of N-treated (Table 3), control (Table 2) and K-treated varieties, respectively.

3. Composition of free amino acids in the must

No great differences were found between the varieties as regards the free amino acid composition; only the quantities of the individual amino acids varied (JUHÁSZ—POLYÁK 1976).

By means of an amino acid analyser, 23 amino acids were identified in the must, of which the following 15 were present in demonstrable quantities in each of the examined varieties (Tables 1—5): Asp, Thr, Ser, Glu, Pro, α-Ala, Val, Ile, Leu, Tyr, Phe, His, γ-amino butyric acid, arginine and ornitine.

Table 3

Changes in the free amino acid composition (mg/100 ml) in the must of nitrogen-treated Rizlingszilváni (RN) grapes (1977)

Amino acid	Date of sampling					
	July 14th	July 26th	August 10th	August 24th	Sept. 6th	Sept. 19th
1. Asparagic acid	2.5	3.23	3.37	5.61	4.12	3.81
2. Threonine	16.38	18.40	12.98	14.20	10.80	14.28
3. Serine			8.40	19.20	8.74	7.57
4. Glutamic acid	11.36	13.85	5.04	13.57	13.51	15.32
5. Proline	+	1.08	5.06	16.70	28.68	26.01
6. Glycine	+	+	+	+		+
7. α-Alanine	3.20	4.03	8.20	9.81	17.24	15.53
8. Cysteine	—	—	—	—	—	—
9. Valine	1.28	1.25	0.63	0.93	1.70	1.95
10. Methionine	+	0.47	+	+	0.63	0.93
11. Isoleucine	0.57	0.94	0.58	0.60	0.65	1.20
12. Leucine	1.14	1.24	0.92	0.98	1.56	2.07
13. Tyrosine	+	0.42	0.48	0.65	0.79	1.16
14. Phenylalanine	1.01	1.44	0.77	1.75	2.29	2.17
15. Histidine	1.16	0.44	0.66	2.01	4.02	4.91
16. γ-Amino butyric acid	0.85	1.57	1.38	2.52	3.72	5.77
17. Lysine	0.74	0.57	+	+	+	0.25
18. Arginine	21.09	50.40	46.90	75.50	115.06	110.20
19. Ornithine	0.27	0.32	0.45	0.64	0.79	1.51
20. β-Alanine	+	+	+	—	+	+
21. 2-Amino butyric acid	+	+	—	—	+	+
22. Tryptophane	+	+	+	+	1.49	2.10
23. Hydroxyproline	+	+	+	+	+	+
Total:	61.64	100.06	95.82	163.67	215.79	216.73

* R∅ = Control Rizlingszilváni, RN = Nitrogen-treated Rizlingszilváni, RK = Potassium-treated Rizlingszilváni, E = Ezerjó, H = Hárslevelű, OR = Olasz rizling, Asp = Asparagic acid, Thr = Threonine, Ser = Serine, Glu = Glutamic acid, Gly = Glycine, Cys = Cysteine, Ala = Alanine, Pro = Proline, Val = Valine, Met = Methionine, Ile = Isoleucine, Leu = Leucine, Tyr = Tyrosine, Phe = Phenylalanine, His = Histidine, Lys = Lysine, Arg = Arginine.

Table 4

Changes in the free amino acid composition (mg/100 ml) in control Rizlingszilváni (R0) grapes during maturation (1978)

Amino acid	Date of sampling						
	July 24th	August 8th	August 21st	Sept. 4th	Sept. 19th	Oct. 2nd	Oct. 17th
1. Asparagic acid	4.82	3.09	10.59	9.80	6.29	3.15	3.11
2. Threonine	16.93	17.85	15.23	18.63	14.28	15.73	13.72
3. Serine	14.30	16.10	17.38	15.31	13.84	15.54	15.20
4. Glutamic acid	10.86	8.30	10.82	13.06	19.87	22.19	19.62
5. Proline	1.17	1.27	1.62	14.79	15.60	42.57	46.65
6. Glycine	0.35	0.10	0.13	0.40	0.45	0.57	0.38
7. α-Alanine	3.47	1.24	2.78	8.25	9.15	13.12	8.34
8. Cysteine	—	—	—	—	—	—	—
9. Valine	1.26	0.46	0.43	1.87	1.85	6.36	6.66
10. Methionine	0.16	0.58	0.38	0.50	0.63	1.76	1.53
11. Isoleucine	0.32	0.38	0.57	1.28	1.72	5.29	5.40
12. Leucine	0.64	0.71	1.45	1.71	2.21	6.65	6.13
13. Tyrosine	0.59	0.64	1.74	1.97	1.91	2.14	1.43
14. Phenylalanine	1.60	0.54	1.41	3.37	3.56	6.81	4.88
15. Histidine	1.41	1.43	3.10	3.26	2.05	2.58	3.19
16. γ-Amino butyric acid	+	0.34	1.94	2.70	2.65	5.07	8.49
17. Lysine	0.28	0.38	0.51	0.52	+	8.33	+
18. Arginine	6.97	11.57	28.95	46.25	57.00	75.45	62.50
19. Ornithine	+	+	+	+	+	+	+
20. β-Alanine	+	—	—	—	+	+	+
21. α-Amino butyric acid	—	—	—	—	+	+	+
22. Tryptophane	+	+	+	+	+	+	+
23. Hydroxyproline	+	+	+	+	+	+	+
Total:	64.63	64.98	99.33	143.67	153.06	225.31	207.23

In addition to these, small quantities of cisteine, β-alanine, α-amino butyric acid, citrulline, hydroxy-proline, tryptophane, glycine and lysine were found in the samples.

The following amino acids accumulated in the fruit in the largest quantities: arginine (100 mg/100 ml), proline (47 mg/100 ml), threonine (23 mg/100 ml), glutamic acid (22 mg/100 ml), serine (19 mg/100 ml), alanine (23 mg/100 ml) and γ-amino butyric acid (8.5 mg/100 ml). The figures represent the maximum possible concentrations.

Changes in the arginine content. Of all free amino acids, arginine accumulates in grapes to the greatest extent during maturation (Figs 3, 4); this increase may be as much as 5—10-fold.

The average value of the correlation coefficient (r) was 0.949 in 1977 and 0.962 in 1978.

The increase in the arginine concentration as a function of time was significant in both years at the $P < 1\%$ level. With regard to the average arginine concentration of the last samples at vintage time, the highest value (68.7 mg/100 ml) was again obtained in 1977 compared to the average values

Table 5

Changes in the free amino acid composition (mg/100 ml) of nitrogen-treated Rizlingszilváni grapes (RN) during maturation (1978)

Amino acid	Date of sampling						
	July 24th	August 8th	August 21st	Sept. 4th	Sept. 19th	Oct. 2nd	Oct. 17th
1. Asparagic acid	4.45	4.81	9.41	8.43	7.56	5.28	3.98
2. Threonine	25.20	12.80	20.60	19.35	17.98	18.87	20.15
3. Serine	12.90	18.81	11.20	12.03	11.22	7.78	6.91
4. Glutamic acid	12.06	9.05	13.01	10.27	10.38	16.80	13.74
5. Proline	0.42	0.68	4.30	8.87	16.43	27.74	22.28
6. Glycine	0.22	0.13	0.20	8.40	0.46	0.56	0.44
7. α-Alanine	3.00	2.14	5.26	7.00	0.28	13.47	9.79
8. Cysteine	+	+	—	—	—	—	—
9. Valine	0.89	0.66	1.00	1.50	2.06	3.61	4.15
10. Methionine	0.24	0.73	0.40	0.53	0.63	1.37	1.55
11. Isoleucine	0.30	0.88	0.53	1.06	1.54	3.01	4.01
12. Leucine	0.60	1.05	1.26	1.43	2.08	4.26	5.21
13. Tyrosine	0.40	1.04	1.43	1.77	1.38	1.99	1.74
14. Phenylalanine	1.72	0.43	1.23	3.65	4.76	6.19	6.59
15. Histidine	1.36	0.87	2.45	2.12	2.22	3.50	2.07
16. γ-Amino butyric acid	+	1.48	1.62	2.96	3.84	10.68	7.41
17. Lysine	0.47	0.45	0.50	+	+	+	+
18. Arginine	4.56	21.71	27.58	33.53	52.75	78.23	68.62
19. Ornithine	—	+	+	—	+	+	+
20. β-Alanine	+	+	+	—	+	+	+
21. α-Amino butyric acid	—	+	+	—	+	+	+
22. Tryptophane	+	+	+	+	+	+	+
23. Hydroxyproline	+	+	+	+	+	+	+
Total:	68.79	77.72	101.98	114.9	143.59	203.28	178.64

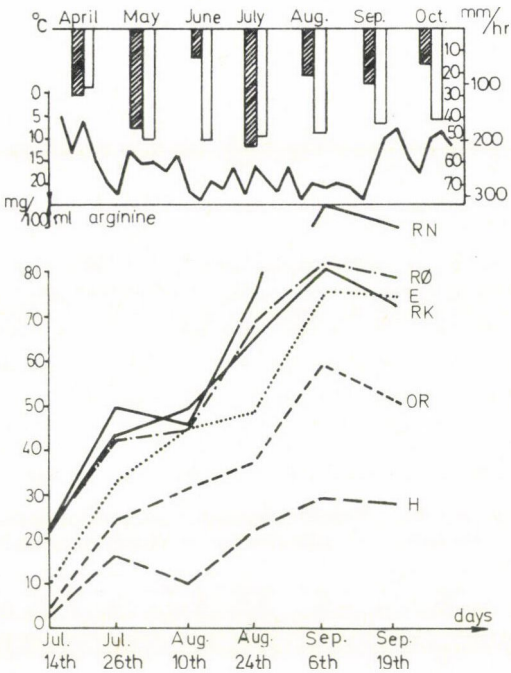

Fig. 3. Change in the arginine content of must samples in various untreated and treated vine varieties during maturation, indicating the temperature (graph, °C), precipitation (line diagram, mm) and light (empty diagram, hours) conditions (1977)

in 1976 (55.3 mg/100 ml) and 1978 (51.6 mg/100 ml). However, in 1977 and 1978 the highest arginine content was found in the last but one sample.

Among the varieties examined Rizlingszilváni had the highest arginine level in the must, with a concentration of 70.2 mg/100 ml on a three-year average.

Rizlingszilváni was followed by Ezerjó and Olasz rizling with arginine concentrations of 53.2 and 43.5 mg/100 ml, respectively, in the must, while Hárslevelű had a concentration of only 30.5 mg/100 ml.

Arginine makes up 23—61% of the total nitrogen content of the must. When studying the effect of nitrogen application on the arginine content of grape must on the basis of the results of three years' analyses it is found that in 1976 and 1977 the arginine concentration in the must samples of N-treated Rizlingszilváni was considerably higher than in the control (Tables 1—3).

In the last vintage samples of 1978 there was hardly any difference in the arginine concentration of the must in untreated and N-treated Rizlingszilváni (Tables 4—5).

Potassium fertilization was shown to reduce the arginine concentration of the must.

Discussion

When evaluating the results of amino acid analyses the role of climatic factors cannot be ignored. Owing to the extremely unfavourable weather conditions in 1976, 1977 and 1978 (Tables 6—7) the sum of heat units measured during the shortened vegetation period in 1977 and 1978 did not reach the average 1400—1600 °C sum of heat units given for Hungarian conditions (KOZMA 1964, 1967) and only approached this value in 1976. Also, the metabolism of the whole vine was adversely affected by the absolute temperature minimum of —16.6 °C and the radiation minimum of —23 °C on 21st February 1980.

The amount of precipitation in the vegetation cycle of the grape-vine was 619 mm in 1975—76, 549 mm in 1976—77 and 490 mm 1977—78. If these precipitation averages are compared to the 20-year average for precipitation between 1955 and 1975, which was 561 mm, it can be seen that the summers of the last two years of the experimental period were extraordinarily poor in precipitation. As regards the weather conditions in 1978, there was an unusually large amount of precipitation in May, June and July compared to the other months; at the same time, the monthly air temperature means in the same period were lower than in the other two experimental years (Table 7).

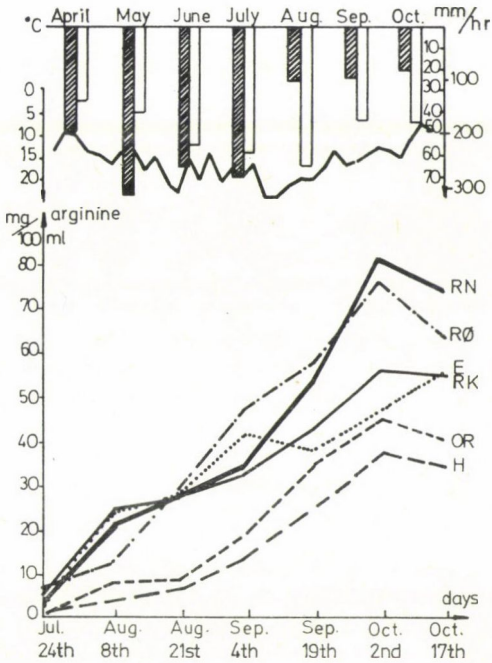

Fig. 4. Change in the arginine content of must samples in various untreated and treated vine varieties during maturation, indicating the temperature (graph, °C), precipitation (line diagram, mm) and light (empty diagram, hours) conditions (1978)

Table 6

Vegetation periods and climatic characteristics at Szigetcsép (1973—1978)

Factors examined	1973	1974	1975	1976	1977	1978
1. Beginning of vegetation	April 13th	March 30th	April 2nd	April 7th	April 17th	April 12th
Last important spring frost	—	April 15th	—	May 1st	April 21st	May 13th
2. End of vegetation	Oct. 14th	Oct. 7th	Oct. 18th	Oct. 26th	Oct. 10th	Oct. 12th
First major autumn frost	—	—	—	—	Sept. 28th	—
3. Length of vegetation (days)	185	192	200	203	177	193
Modified by frost damage (days)	—	176	—	179	160	162
4. Effective sum of heat units in the vegetation period (°C)	3436.9	3327.0	3647.7	3502.4	3206.2	3141.5
Modified for frost damage (°C)	—	3147.2	—	3230.2	2979.2	2781.0
5. Active sum of heat units during vegetation (°C)	1586.9	1407.0	1647.7	1472.4	1436.2	1321.5
Modified for frost damage (°C)	—	1387.2	—	1440.2	1379.2	1244.8
6. Annual mean temperature (°C)	11.7	11.3	11.7	10.0	11.1	10.1
Mean temperature during vegetation period (°C)	18.6	17.3	18.2	17.3	16.9	15.9
Mean temperature during vegetation period modified for frost damage (°C)	—	17.9	—	18.0	18.6	17.2
7. Annual precipitation total, mm	413.0	668.3	582.2	617.6	446.9	449.0
Precipitation during vegetation period, mm	239.5	393.1	460.0	424.5	195.4	283.0
Precipitation during vegetation period modified for frost damage, mm	—	386.0	—	359.7	186.2	222.8

Of the free amino acids the amount of acidic amino acids was larger in the 1978 must samples (Tables 4—5) than in the 1977 samples (Tables 2—3). Thus, the larger amount of precipitation during the vegetation period and the lower sum of heat units seem to have a positive influence on the proportion of acidic amino acids (asparagic acid, glutamic acid).

The arginine content of the must was higher in 1977 than in 1978, presumably due to the higher sum of heat units and the lower amount of precipitation in 1977.

The grape-vine, like most plants, takes up nitrogen mainly in the form of nitrate. The abundant rain from April to June 1978, which made up 60%

Table 7

Meteorological data at Szigetcsép (1976, 1977, 1978)

Month	Monthly and annual mean temperature (°C)				Monthly and annual precipitation total (mm)				Monthly and annual total sunshine hours			
	1976	1977	1978	3-year average	1976	1977	1978	3-year average	1976	1977	1978	3-year average
Jan.	0.8	—0.1	0.1	0.2	25.0	41.0	22.0	29.3	56.0	45.0	63.0	54.7
Feb.	—0.1	4.2	0.4	o.5	3.0	43.0	28.0	28.0	93.0	88.0	57.0	79.3
Mar.	2.8	9.0	7.2	6.3	28.0	58.0	27.0	37.7	156.0	165.0	154.0	158.3
Apr.	12.4	9.7	10.4	10.8	65.0	30.0	48.0	47.7	169.0	108.0	138.0	138.3
May	17.1	17.1	14.4	16.2	20.0	45.0	77.0	47.3	199.0	203.0	158.0	186.7
Jun.	20.4	21.2	18.7	28.1	30.0	13.0	64.0	35.7	207.0	204.0	217.0	209.3
Jul.	23.1	20.8	20.2	21.4	105.0	54.0	69.0	76.0	211.0	197.0	233.0	213.7
Aug.	19.2	20.1	20.1	19.8	42.0	21.0	25.0	29.3	193.0	194.0	248.0	211.7
Sep.	15.3	14.9	15.7	15.3	92.0	25.0	24.0	47.0	122.0	176.0	176.0	158.0
Oct.	11.6	12.0	11.6	11.7	80.0	16.0	21.0	39.0	99.0	165.0	180.0	148.0
Nov.	7.0	5.7	2.2	5.0	30.0	51.0	16.0	35.7	53.0	81.0	16.0	50.0
Dec.	0.1	—1.2	0.8	—0.1	99.0	29.0	28.0	52.0	37.0	32.0	37.0	35.3
Total	—	—	—	—	619.0	446.0	449.0	509.6	1595.0	1658.0	1677.0	1643.3
Mean	10.8	11.1	18.1	10.7	—	—	—	—	—	—	—	—

of the annual precipitation, promoted the leaching of nitrates and hindered pollination and fructification.

The reductase activity of nitrate can be induced by a substrate (FARKAS 1978), so the lower nitrate supply in the soil, caused by the adverse conditions in the year 1978, decreased the reductase activity of the nitrate.

As a consequence, the optimum conditions for nitrogen absorption were not available in 1978. Hence the negligible difference in free amino acid content between the must samples of untreated and treated Rizlingszilváni vines.

The effect of nitrogen treatments is only felt under optimum temperature and edaphic conditions. This is presumably why the 1977 results showed a closer correlation between the total nitrogen and free amino acid contents.

Of the free amino acids, the level of arginine in the grapes increased most noticeably due to nitrogen treatment during maturation. This phenomenon is connected with the essential functions of detoxication, nitrogen storage and energy storage that arginine fulfils in the metabolism of the plant.

All in all, the investigations have revealed a positive correlation between the arginine content of the fruit and the nitrogen status of the vine; the arginine content of grapes can therefore be suggested for use as an indicator of the nitrogen status of the grape-vine.

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GROWTH AND CHLOROPHYLL CONTENT IN CALLUS CULTURES OF BETAINE-PRODUCING SUGARBEET

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In callus subcultures produced from various sugarbeet organs and maintained on Linsmaier—Skoog culture medium the significant initial differences in growth can still be demonstrated, though to a reduced extent, after six months. The most intensive growth was displayed by the callus prepared from storage tissues. In cultures prepared from the hypocotyl and cotyledon of the seedling the increase in fresh and dry weight was lower. Intensive betaine accumulation was observed in the tissue cultures. To inhibit this and stimulate growth successful use was made of 5 mg/l homocystine or 5 mg/l methionine in the culture medium. Glutathione also promoted greening, but had an inhibitory effect on growth even at a concentration of only 2 mg/l. Although cysteine-HCl is a growth stimulator at a concentration of 5—20 mg/l it causes intensive tissue browning. Compounds which inhibit the accumulation of betaine chiefly increase the amount of chlorphyll-*a*, while the chlorophyll-*b* content increases to a lesser extent. In the presence of 5 mg/l homocystine or methionine, or of 2 mg/l glutathione, the amount and *a*/*b* ratio of the chlorophylls increase.

Introduction

Sugarbeet tissue cultures were earlier produced by ATANASSOV—KIKINDONOV (1972), ATANASSOV *et al.* (1978) and BUTENKO *et al.* (1972) on GAMBORG—EVELEIGH (1968) culture medium from both sterile embryonic plants and storage tissues. WELANDER (1974) produced callus cultures from sterile sugarbeet hypocotyls, from the petiole of a six-week-old plant and from anthers, and induced root formation from these on a special culture medium with a low macroelement concentration by varying the ratio of auxin to kinetin. ROGOZINSKA—GOSKA (1976) produced sugarbeet callus cultures from isolated anthers of diploid and tetraploid varieties on LINSMAIER—SKOOG (1965) culture medium.

In tissue cultures produced from various organs of sugarbeet seedlings, and from the storage tissues of 5-month-old plants raised in a hotbed and maintained on Linsmaier—Skoog culture medium, intensive betaine accumulation was observed (BOGNÁR—MARÓTI 1979). Accelerated betaine synthesis and a subsequent betaine accumulation in sugarbeet tissue cultures have been pointed out by a number of authors (CONSTABLE 1967, MISAWA 1977, WAGNER—VOGELMANN 1977), and can be found — though less frequently — in isolated cultures of other species as well (SETHI—CAREW 1974). The accumula-

tion of betaine and the discoloration of the tissues cause rapid senescence of the cells and early destruction in isolated cultures.

To suppress the discoloration of tissues various reducing agents, including amino acids containing sulphydryl groups, are often added to the culture media (EDELMAN—HANSON 1972). In the present experiments, aimed at maintaining the juvenile stage and suppressing the synthesis of betaine, the effects of various sulphur-containing amino acids on growth and chlorophyll content were studied.

Material and method

To produce isolated tissue cultures of sugarbeet (*Beta vulgaris* L. provar. *altissima* Döll. BETA poli M/102) various organs of 8—10-day-old seedlings kept sterile on Hoagland macroelement culture medium, and petioles and storage tissues of 5-month-old plants raised in a hotbed were used. Callus formation and the further development in isolated plant organs were described earlier (BOGNÁR—MARÓTI 1979). In the present investigations 6—8-month-old subcultures were used and these were maintained on LINSMAIER—SKOOG (1965) culture medium (NAA: 5 mg/l; BAP: 2 mg/l; saccharose: 30 g/l; agar: 8 g/l; pH = 5.6) before autoclaving. Compounds used to regulate the betaine biosynthesis were added to the culture medium through a membrane filter (GELMAN) immediately after the autoclave treatment. 500 mg callus was added to each 50 ml of the culture medium, then the inocula were incubated under constant conditions (at a temperature of 26 ± 2 °C, 16 hours illumination 8 hours darkness) for 1—6 weeks when studying the time curve of growth and for 4 weeks when the action of sulphur-containing amino acids was traced. Among the growth parameters the increase in fresh weight was measured. To determine the dry weight, callus removed from the test-tube was kept at 100 °C for 2 hours, then at 60 °C for 24 hours. The samples were cooled to room temperature in an exsiccator and measured immediately. The betaine content was deduced from the amount and ratio of chlorphyll-*a* and chlorophyll-*b*.

For examinations of chlorophyll content callus was taken from storage tissue which was growing and colouring the most vigorously. On each 50 ml of the culture medium 500 mg of the tissue were inoculated and incubated for 4 weeks under the conditions described above. The chlorophylls were extracted from the callus in a braying mortar with 80% acetone in the presence of a little $MgCO_3$. The homogenate was filtered and washed with 80% acetone. The acetone solution of the pigments was concentrated in a vacuum.

The pigment content of the mixture was determined by photometry with the two-wavelength method using the following formulae (ARNON 1949):

chlorophyll-*a* (mg/l) = $12.7\ E_{663} - 2.69\ E_{645}$
chlorophyll-*b* (mg/l) = $22.9\ E_{645} - 4.68\ E_{663}$
chlorophyll-*a* + *b* (mg/l) = $8.02\ E_{663} + 20.2\ E_{645}$

The data were obtained by averaging the measurements from 6 test-tubes in each of two experimental series; in addition to the averages the standard deviation values are also indicated.

Results

As can be seen from the literature, the extent of callus formation and the growth of secondary callus depend on the genotype and physiological condition of the plant, as well as on the culture medium. These earlier observations are confirmed by the experimental results (Fig. 1). Callus cultures prepared from storage tissue display more intensive growth than those produced from seedling organs. The significant initial differences in the primary culture may be due to the different endogenous hormone contents of the

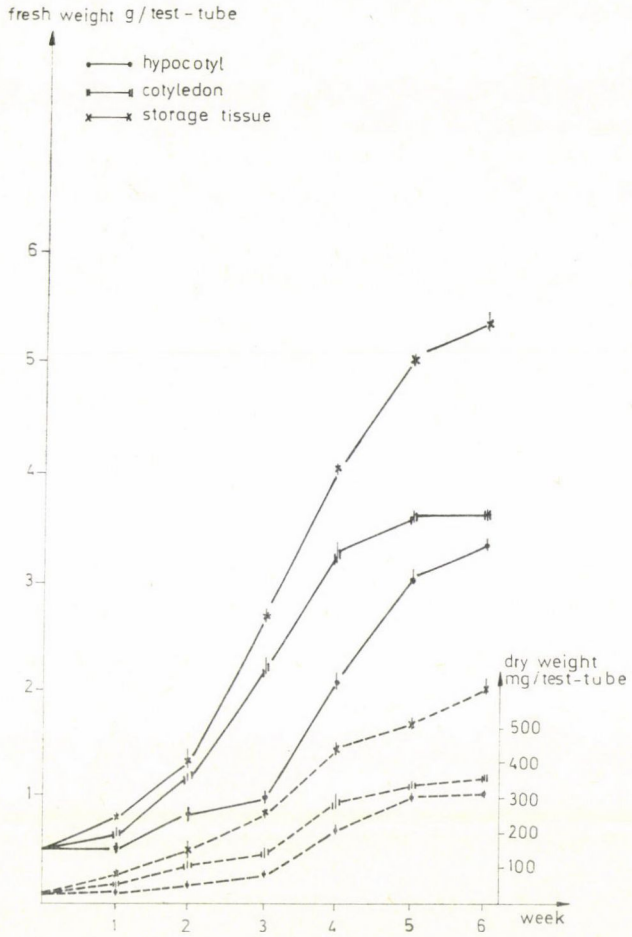

Fig. 1. Fresh weight and dry weight increase in callus cultures produced from various organs of sugarbeet

inocula forming the primary callus, and to the different culture medium requirements and regulator response of variedly differentiated cells. In the course of inoculations following the development of the primary callus differences in the growth of the subcultures can still be observed. The gradual disappearance of the great initial differences may be partly connected with the change in the cell metabolism (habituation), or with the genetic instability found in the callus (BAYLISS 1973), which has also been demonstrated in sugarbeet tissue cultures with high chromosome numbers (ATANASSOV *et al.* 1978).

The time curve of the dry weight increase, like that of the fresh weight increase, is sigmoid in character. The dry matter conrent in subcultures prepared from the hypocotyl and cotyledon of the seedling is lower than in

cultures produced from the storage tissue. The percentage dry weight increases as a function of the incubation time, rising from 7.5 to 9.7% for the callus prepared from the cotyledon of the seedling, and from 10.3 to 11.3% in cultures produced from storage tissue.

Studying the effect on growth of sulphur-containing amino acids a concentration dependence of optimum character was found, except for glutathione (Fig. 2). In the callus culture prepared from storage tissue cysteine-HCl applied at a concentration of 10 mg/kg caused a considerable increase in fresh and dry weight, and even at a concentration of 20 mg/kg had some stimulative effect on growth. The optimum concentration of homocystine and methionine is 5 mg/kg; in the case of 10 mg/kg the growth is less intensive than in the control. The increase in fresh weight caused by either of these two compounds is not accompanied by a similar change in the dry matter content. At the optimum concentration the compounds increase the water level in the cells. Even at the lowest concentration applied (2 mg/kg) glutathione checks the increase in fresh weight. An increase in concentration strengthens the inhibition. In the case of homocystine the amount of dry matter increases as a function of concentration. With the other compounds a supraoptimum con-

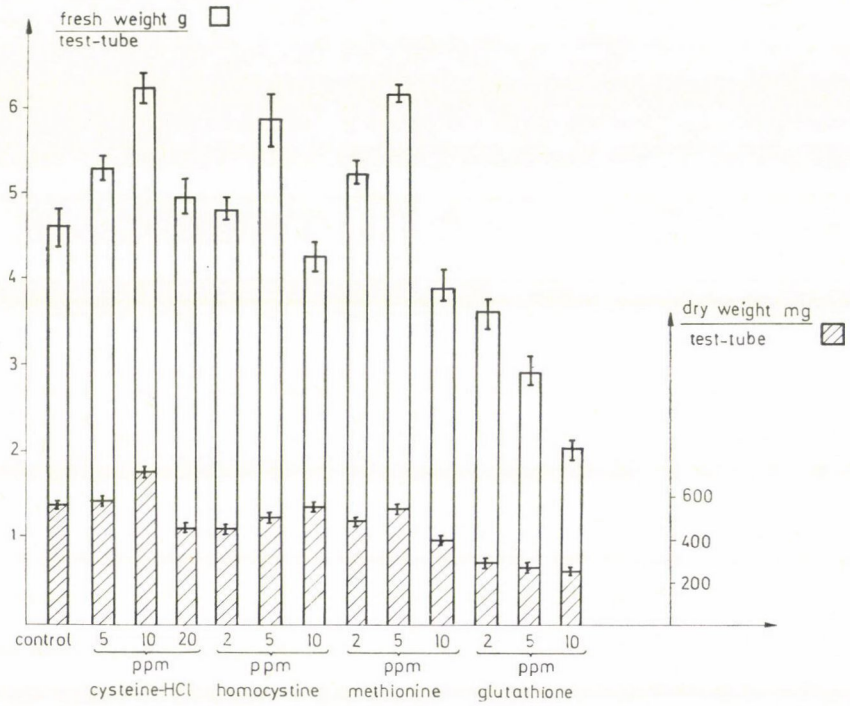

Fig. 2. Effects of some sulphurous amino acids on fresh weight and dry weight increase in callus cultures prepared from storage tissues

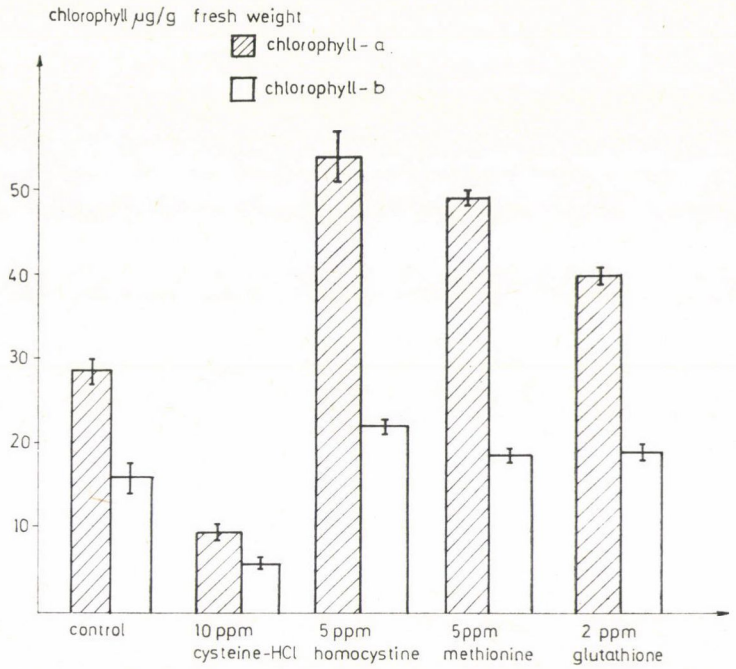

Fig. 3. Effects of some sulphurous amino acids on the amounts of chlorophyll-*a* and chlorophyll-*b* in sugarbeet callus culture

centration decreases the dry matter, though to a lesser extent than the fresh weight.

The effects of the examined compounds on chlorophyll-*a* and chlorophyll-*b* contents were studied at concentrations optimum for growth, and in the case of glutathione at 2 mg/kg (Fig. 3).

The amounts of green pigments are generally smaller in callus than in green leaves and shoots (LAETSCH—STETLER 1965, CHEN—VENKETESWARAN 1968). The chlorophyll *a*/*b* ratio considerably differs from that found in vivo; it is generally lower than in the case of intact tissue (DOBBERSTEIN—STABA 1966, MAHLBERG—VENKETESWARAN 1966). Cysteine-HCl increases the betaine formation and reduces the amounts of chlorophyll-*a* and chlorophyll-*b* to a considerable extent. The other compounds increase the chlorophyll-*a* content significantly, and that of chlorophyll-*b* to a lesser extent. The ratio of the two pigments rises, approaching the value measured in intact tissues.

Betaine is an important derivative of glycine, a biological methylating agent, and a special metabolite characteristic of the family *Chenopodiaceae*. It is transformed into methionine through the agency of homocysteine, a compound produced from S-adenosyl-methionine in the course of methylating reactions. Considering the biochemical pathway of the betaine metabolism,

it is probable that in the tissue cultures the latter was indirectly influenced by cysteine-HCl and glutathione, while homocystine and methionine presumably had a direct regulatory effect on it.

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COMPOSITION OF LOLIUM MULTIFLORUM AND CHANGES IN ITS NUTRITIVE VALUE IN THE COURSE OF GROWING

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Pure stands of Lolium multiflorum, dried artificially, were examined for nutrient composition and for changes in the nutrient content during the development of the first growth on 7 occasions. The effect of organic matter fed in different quantities on the digestibility of crude nutrients was also studied. The crude protein content was found to fall from 28.5% to 10.4%, while the crude fibre content increased from 18.5% to 27.6% and the lignin content from 6.3% to 9.2%. The amount of organic matter fed influenced the digestibility of the individual nutrients, but not to a statistically demonstrable extent. While the amount of indigestible crude protein was nearly identical during the whole growing period, that of indigestible crude fibre increased parallel to the total amount of crude fibre, i.e. the proportion of digestible crude fibre remained nearly the same. The lignin content partly exceeded the amount of indigestible crude fibre in the examined period, which suggested that the digestibility of lignin might show a different trend.

Introduction

The feeding value of the plant communities of pastures and meadows varies not only with the botanical composition (grasses, legumes, other plants), but also depends on changes in the nutrient contents of the individual components during the growing period. This also applies to plant stands consisting of grasses alone, because the grass species have different growing characteristics. In order to be able to register changes caused only by the growing period, Lolium multiflorum, a genetically uniform species, was used in the present investigations.

It is well known that the changes occurring in the crude nutrients during development are mainly characterized by the opposing trends in crude protein and crude fibre. Besides analysing these two components the utilization of crude protein as a function of the growing period, and the effect of lignin on the digestibility of crude fibre were also studied. It is generally accepted that lignin is digested to a very low extent, if at all, and that with an increase in the lignin content not only the crude fibre, but other organic matter, too, becomes less digestible.

In addition, the effect of organic matter fed in various quantities on the utilizability of raw nutrients was examined. Grass samples were collected

from the trial plots for the examinations every week between 5th May and 16th June, on a total of seven occasions. The samples were dried in a thermostat under identical conditions. The seven sampling dates made it possible to study the maturation phase of the grass from the beginning of grazing up to the first cutting.

Material and method

Utilization experiments were carried out with wethers (three per treatment) in the usual manner (WÖHLBIER 1953). The animals were fed all seven artificially dried experimental samples, in such a way that in the various experimental phases the animals were given three different quantities of each sample, as calculated on the basis of the organic matter content.

The same three animals were given the following daily rations from the seven experimental materials:

1st treatment: 800 g organic matter/animal a day
2nd „ : 650 g „ „ „ „
3rd „ : 500 g „ „ „ „

Altogether 21 utilization experiments were performed, each experimental phase consisting of 20 days; the total number of experimental days was thus 420. This long experimental period accounted for the fact that the experimental material was fed in an artificially dried state, because changes might have occurred in the grass even in cold storage.

The crude nutrients were determined by the Weende analysis, while the lignin was determined using a method earlier elaborated and applied by the authors (FARRIES 1969, RÉGIUS-MŐCSÉNYI 1970).

Results

Changes in crude nutrients. Changes in the composition of crude nutrients during maturation are shown in Table 1. The data in the table show that there was an absolute decrease of 18% and a relative decrease of 64% in the crude protein content in the course of experiment. At the same time the amount of crude fibre showed an absolute increase of 9% and a relative

Table 1

Ratio of crude nutrients to dry matter

Cutting	Organic matter	Crude protein	Crude fat	Crude fibre	Lignin	Crude ash	N-free extracts
5th May	86.46	28.46	4.38	18.50	6.27	13.54	35.12
12th May	88.40	20.25	4.83	20.24	5.54	11.60	43.08
19th May	88.49	15.63	3.77	23.74	7.42	11.51	45.35
26th May	90.95	13.63	3.10	24.35	7.95	9.50	49.87
2nd June	98.97	12.13	3.11	26.18	8.35	9.03	49.55
9th June	91.59	10.06	2.68	28.39	8.75	8.41	50.46
16th June	89.36	10.38	2.87	27.58	9.22	10.64	48.53

Table 2

Percentage digestion coefficients

Crude nutrients		Date of cutting						
		5th May	12th May	19th May	26th May	2nd June	9th June	16th June
Organic matter	a	85.21	83.13	80.84	77.64	75.09	67.63	67.00
	b	86.06	84.50	82.29	78.52	77.08	69.68	68.03
	c	85.53	82.94	82.89	78.94	76.85	76.00	72.26
Crude protein	a	83.60	78.64	76.88	71.89	71.54	65.21	64.81
	b	83.74	79.42	77.64	75.55	72.97	63.95	67.38
	c	80.29	78.67	76.02	73.48	74.02	58.86	70.69
Crude fat	a	58.40	60.00	64.38	53.54	68.20	60.93	57.85
	b	61.38	61.89	62.81	62.41	66.08	60.40	64.68
	c	57.47	59.72	63.15	60.35	65.16	60.79	70.94
Crude fibre	a	92.59	88.06	81.97	74.28	71.92	63.77	62.95
	b	94.85	90.09	83.78	76.10	75.03	66.93	65.23
	c	92.33	87.37	84.43	78.46	74.50	68.17	70.49
N-free extracts	a	85.98	85.52	82.99	82.35	78.07	70.77	68.68
	b	86.38	86.80	84.73	82.13	79.86	72.94	70.53
	c	89.69	85.51	86.09	81.82	79.50	73.74	73.68

a = 800 g organic matter/day/animal
b = 650 g organic matter/day/animal
c = 500 g organic matter/day/animal

increase of 49%. The crude fat and ash contents were somewhat reduced, while the organic matter content increased slightly and the nitrogen-free extracts rose considerably. The lignin content increased more or less parallel to that of crude fibre.

Utilization of crude nutrients. Table 2 shows the digestion coefficients (averaged for 3 animals) in the successive developmental phases of the grass, according to the amount of organic matter fed. As seen in Table 2, all nutrients except crude fat, which is of no great importance, became less digestible in the course of development, irrespective of the amount of organic matter fed. Within the same growth period, the digestibility of the nutrients showed a slight, though statistically non-significant, increase when decreasing quantities of organic matter were fed.

Changes in nutritive value during the growing period. Since feeding the organic matter at three different rates had no significant effect on the utilization of the nutrients, and digestibility did not always increase with decreasing doses, the utilization coefficients of grasses cut at the same time and fed at three rates were averaged. In this way the digestible protein content and the

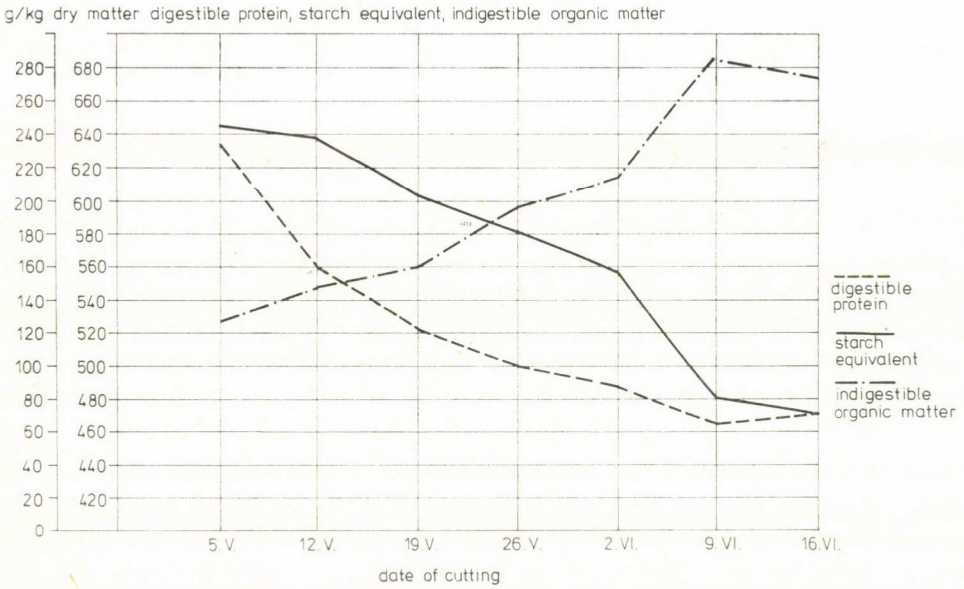

Fig. 1. Changes in digestible protein, starch equivalent and indigestible organic matter in Lolium multiflorum

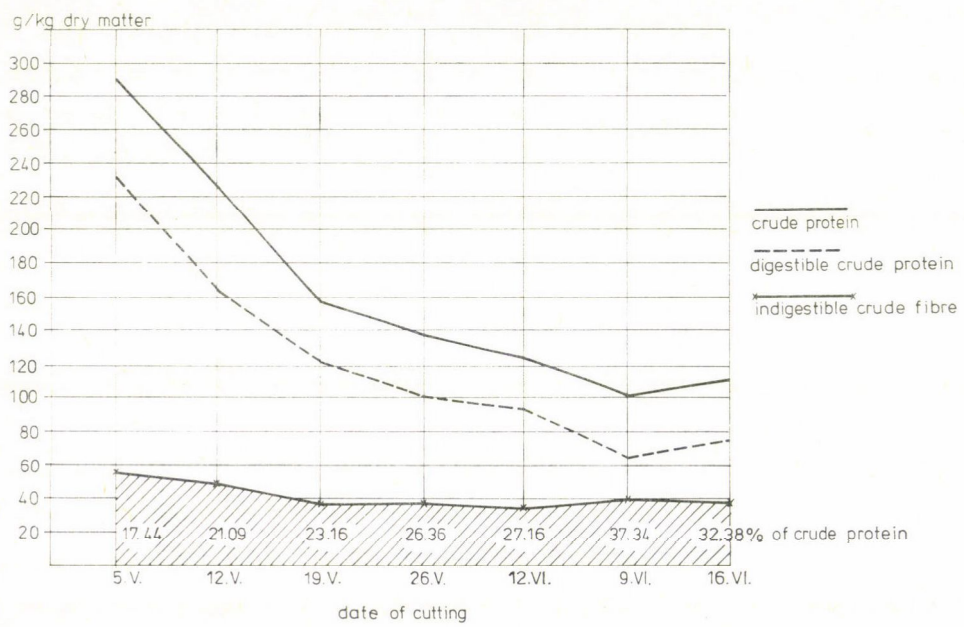

Fig. 2. Changes in crude protein and its digestibility in Lolium multiflorum

starch equivalent for grass samples cut on seven occasions were calculated using the average of all the 3×3 digestion coefficients.

Changes in the nutritive value during the maturation of the grass are shown in Fig. 1. The amount of digestible crude protein per kg dry matter decreased from 235 g on 5th May to 70 g by 16th June. During the same period the starch equivalent fell from 642 g to 470 g, while the indigestible organic matter increased from 125 g to 276 g.

Changes in the digestibility of crude protein during the growing period. According to Fig. 2, the crude protein content and the digestibility decreased at about the same rate parallel to maturation. At the same time the indigestible part of the crude protein changed only slightly. The indigestible part amounted to 50 g/kg dry matter on 5th May and 34 g/kg dry matter on 16th June, which means an increase from 17.44% to 32.28% relative to the total amount of crude protein.

Digestibility of crude fibre during the growing period. Fig. 3 gives the data for crude fibre. From 5th May to 16th June the crude fibre in the dry matter content rose from 185 g to 265 g, while the digestible portion increased from 173 g to only 183 h. This shows that as the grass matures the amount of indigestible crude fibre increases: in the present experiment from 13 g/kg to 93 g/kg dry matter, i.e. from 7% to 34% of the total amount of crude fibre. The lignin content increased from 63 g to 92 g during this period. The lignin content expressed as a percentage of crude fibre hardly changed over the whole experimental period; it ranged between 30 g and 34 g.

Conclusions

The results obtained in the experiment primarily confirm the changes known to occur in the crude nutrients and in the nutritive value. Several papers on this subject (grass mixtures, grasses from meadows and pastures) are referred to by FARRIES (1966).

In the present experiment the utilization coefficients and nutritive value of *Lolium multiflorum* were studied, together with the changes occurring in the course of development. The effect of the nutrient supply on utilization was also examined. In spite of the fact that the difference between the amounts of nutrients fed was considerable, it was almost impossible to observe the same trend in utilization for the three rates (800, 650, 500 g organic matter/animal a day) at which grass from the same growth was fed, though the digestibility of crude protein, crude fibre and nitrogen-free extracts showed a slight tendency to increase as the amounts of organic matter fed decreased. Since, however, the differences between animals fed the same quantities were greater than those between the average values for the individual phases, the dif-

ferences are not significant. The nutritive value was always calculated using the averaged digestion coefficients of three phases for grass fed at the same developmental stage, i.e. the digestion coefficient is the results of 3×3 animals.

The grass from the first cutting had a high digestible crude protein content, which can be explained by the very early date of sampling (5th May). The first sampling approximately coincided with the beginning of the grazing season. This observation does not apply to the starch equivalent, the reason for which can be seen from the values obtained in the analysis of crude nutrients: from the first to the second sampling the absolute value of the crude protein content decreased by about 8%, while the amount of nitrogen-free extracts rose by about the same percentage. This shift undoubtedly reflects, in the main, the effect of maturation, and also represents the greatest reduction, or rather increase, for these two nutrients over the whole experimental period. Since these opposing shifts compensate each other when calculating the starch equivalent, the value of the latter was about the same in the first two samples.

The nutritive value of the grass samples was much higher throughout the experiment than those given for hay in the standard, which can probably be explained by the careful drying (ANONYMOUS 1966).

According to the results of crude protein analysis (Fig. 2) the amounts of crude and digestible protein decreased at the same rate during the growing

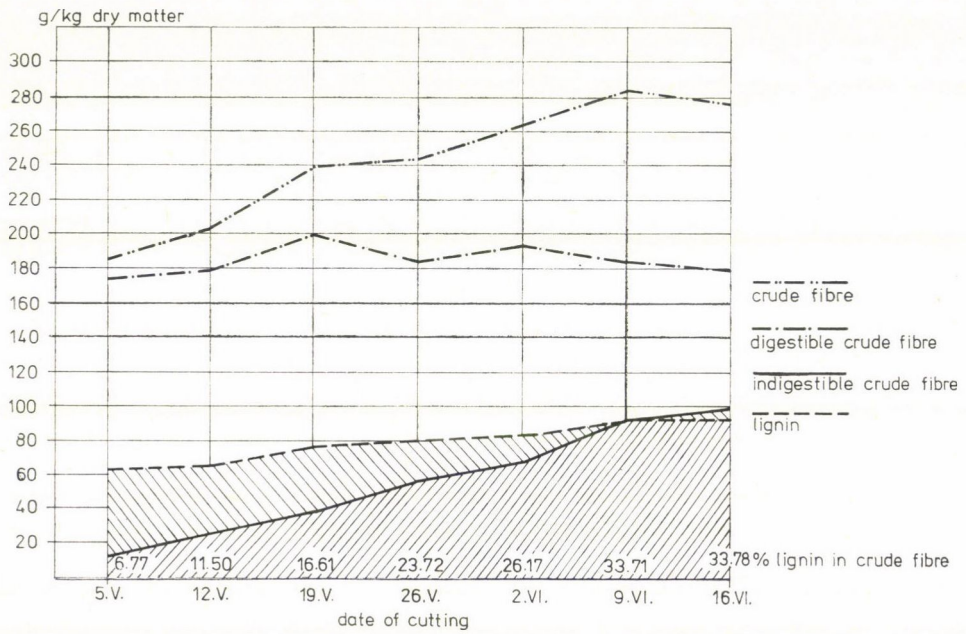

Fig. 3. Changes in the amount and digestibility of crude fibre and in the lignin content of Lolium multiflorum

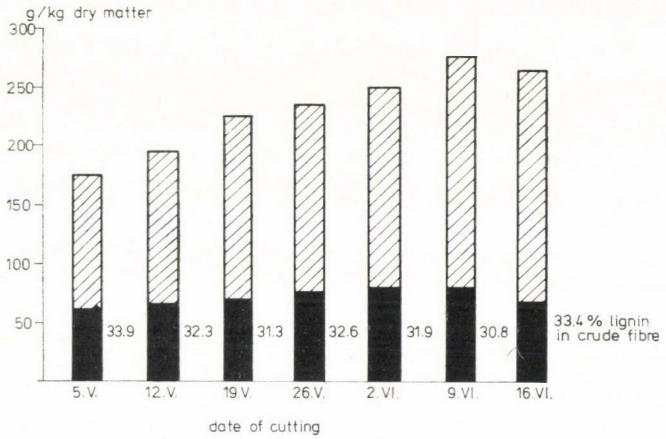

Fig. 4. Crude fibre and lignin content in Lolium multiflorum in different periods of vegetation

period, while the indigestible portion remained nearly unchanged. The reduction in indigestible crude protein was only 16 g/kg, while that in the total amount of crude protein was 181 g/kg, which means a relative increase in the indigestible part from 17% to 32% of the crude protein content. A similar conclusion was reached by NEHRING (1966) and FARRIES—RÉGIUS-MÖCSÉNYI (1970).

Changes in the crude fibre and digestible crude fibre contents were not parallel to those observed for crude protein; with an increase in the crude fibre content the indigestible part also increased, both absolutely and relatively. The amount of digestible crude fibre thus remained more or less unchanged during the whole period of investigation, while its digestibility fell from 90 to 65%.

Changes in the digestibility of the crude nutrients can be traced back to two causes: either there is a change in the chemical composition, or a shift in the ratio of readily to not readily digested nutrients. Nutrients which are initially easy to digest may become bound to less easily digested ones, whereby they become unavailable for chemical or biological predigestion.

In the crude fibre complex the lignin is generally considered to be a highly indigestible component; with an increase in the lignin content the digestibility of crude fibre is greatly reduced (LAUBE 1960, NAUMANN 1940, KAMSTRA *et al.* 1958).

According to the results of experiments on isolated lignin the digestibility of lignin depends to a great extent on its composition and origin. The ratio of the soluble to the less soluble part of the lignin fraction may have a decisive influence on the utilizability of lignin, or — and this is more important — on a possible inhibition of the digestibility of other nutrients by lignin. According to the present experiment the composition of lignin seems to change

depending on the stage of maturation, and this in turn involves a change in the digestibility as well.

In spite of the fact that the amount of lignin relative to that of crude fibre was more or less constant in the examined phase of development (34—30%, Fig. 4), the amount of indigestible crude fibre remained far below the lignin content until the 5th cutting (2nd June). (Indigestible crude fibre: 13—93 g/kg dry matter; lignin: 63—92 g/kg dry matter.) It was only in the last sample that the lignin content was equal to the amount of indigestible crude fibre. This suggests that some of the lignin was digested to some extent.

According to Fig. 3 this digestibility may be as much as 80% in very crop used for preservation was cut (at the end of May or beginning of June) this was reduced to 28% (22 g digestible from a total of 80 g/kg dry matter) or 19% (16 g from a total of 84 g/kg dry matter). In the subsequent phases of maturation the total amount of lignin seems to become indigestible.

However, this hypothesis can only be proved on the basis of a differentiated analysis of the carbohydrate fraction. It remains to be seen in further experiments whether there is any correlation, and if so how close, between the indigestible crude protein and the indigestible lignin contents.

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VARIATION IN THE SELECTIVITY OF THE ANTIDOTE COMBINATION EPTC PLUS AD-67 IN THE FUNCTION OF CERTAIN GROWTH FACTORS

By

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As a result of research and development work in the field of herbicide antidotes a new herbicide/antidote combination, consisting of 72.5 w.% EPTC and 7.5 w.% AD-67 antidote [N-dichloro-acetyl-1-oxa-4-azaspiro-(4,5)-decane] was introduced on the Hungarian market in 1979. This preparation showed excellent weed-killing activity accompanied with good selectivity in maize cultures in the greenhouse and on a field scale alike. In the first year of large-scale application the experience obtiined proved the relevancy of the experimental observations. Under the extreme climatic conditions of that year (1979) morphological changes and phytotoxicity to maize appeared to a negligible extent and, with the exception of a few cases, the preparation showed good to excellent weed-killing efficiency. The experimental work aimed to produce more detailed knowledge on factors which, under field conditions, may render this combination harmful to maize. This work has been carried out by making comparisons between data collected on certain damaged maize-fields and data relating to undamaged fields treated with the herbicide + antidote combination. Computerized techniques were used for making these comparisons. It proved possible to explore certain factors which may adversely influence the selectivity of EPTC plus AD-67 combination(s) under field conditions. These factors are: *a)* slow emergence of seedlings followed by weak development of plants for reasons other than herbicide treatment; *b)* overdosing of the herbicide, and *c)* unfavourable climatic conditions, i.e. a long, dry, hot period after the application of the herbicide, followed by heavy rain bringing a large amount of water within a few days.

Introduction

In recent years world-wide interest has been aroused in increasing the selectivity of certain thiocarbamate herbicides. The concept of using so-called antidotes with thiocarbamates was established by Hoffman (cit. SLIFE 1978). As a result of his work, Gulf Chemical (USA) introduced the application of NA in the late 60's as a protectant against injuries caused by thiocarbamates to maize. This compound was applied in the form of seed-dressing. BURNSIDE *et al.* (1971) reported that NA significantly decreased injuries to maize caused by EPTC (S-ethyl-N,N-di-n-propyl-thiocarbamate) and Buthylate (S-ethyl-N,N-di-isobutyl-thiocarbamate). In the early 70's Pallos—Casida (Stauffer Chem. Co., USA) reported on a number of compounds showing good antidotal activity to thiocarbamates (ANONYMOUS 1972). Among these compounds can be found N,N-diallyl-2,2-dichloro-acetamide (R-25788), which, as shown

by CHANG *et al.* (1976) has the activity resembling that of NA but also has a great advantage over it, namely: R-25788 is readily combinable with the active herbicide material during the formulation phase in the factory.

At present, the Stauffer Chem. Co. commercializes two types of thiocarbamate plus antidote combinations applicable for weed control in maize. These are: *a)* EPTC plus R-25788, and *b)* Buthylate plus R-25788. These combinations are in world-wide use, although SLIFE (1978) indicated that in rare cases compounds of the type N,N-diallyl-substituted-dichloro-acetamide might not offer protection to maize against damage induced by thiocarbamate herbicides. The reason for this, in Slife's opinion, was that under certain conditions the antidote R-25788 would undergo degradation faster than EPTC.

BURT—AKINSOROTAN (1976) came to the conclusion that antidotes of the N,N-diallyl-substituted-dichloro-acetamide type significantly reduce, but cannot completely eliminate injuries to maize by thiocarbamates. These authors pointed out that factors influencing the occurrence of phytotoxic phenomena linked to thiocarbamates are still not fully understood, so the results of laboratory-scale experiments on the role of soil moisture and temperature are not clear.

In spite of all these uncertainties the demand for antidoted EPTC has significantly increased recently.

As the result of research and development on thiocarbamate untidoes in Hungary, the first Hungarian EPTC plus antidote combination, containing 72.5 w.% EPTC and 7.5 w.% AD-67 (N-dichloro-acetyl-1-oxa-4-azaspiro-(4,5)-decane), was introduced in 1979. This combination proved to be an excellent and highly selective weedkiller for the protection of maize hybrids, in the greenhouse and field alike. In the first year of large-scale practical application the experience obtained proved the expectations based on exploratory field trials. In that year (1979), although very extreme climatic conditions prevailed throughout Hungary, morphological changes ranging from 5 to 15% could only be observed on about 0.5% of the total growth area treated with this combination, while a phytotoxicity degree of 1 to 5% could be observed on about 1.0% of the growth area. At the same time the efficiency of the combination in weed killing proved to be good to excellent on the total growth area. The work presented here was aimed at exploring factors which, under rield contitions, might cause the occurrence of phytotoxicity in EPTC plus AD-67 combination(s). In other words: it was hoped to find the climatic and agrotechnical factors which played a role in causing otherwise (under normal conditions) selective herbicide combinations to shown phytotoxicity in certain fields.

Materials and methods

The collection of data on the large-scale application of the new EPTC plus antidote AD-67 combination was based on sending out 1200 questionnaires to 304 state and collective farms throughout the country. 136 of these were returned, 86 of which gave complete information, including a few indicating some degree of phytotoxicity of the combination.

Thirty possible influencing factors were analysed (m = 30) related to the eighty-six areas (n = 86). The average values of the factors, together with their standard deviation, are represented in Table 1. Factor No. 11 in this table relates to the quality of soil preparation and is coded as follows: 5 = optimal; 4 = good; 3 = medium; 2 = weak, and 1 = poor. Factor No. 12 in Table 1 relates to the nature of seedling emergence and is coded as 3 = good; 2 = average; 1 = poor/weak. Factor No. 28 represents the density of weed killing in the following degrees: 0 = very good weed killing; 1 = good weed killing; 2 = medium weed killing; 3 = weak weed killing; 4 = poor weed killing, and 5 = no weed killing was observed.

As a method for the investigation of the data, regression analysis of two variables and factor-analysis (the latter of which is applicable for finding correlations amoung multivariable quantitative factors; SVÁB—NAGY 1977) were used. The data were processed on the computer at the University of Agricultural Sciences, Gödöllő, Hungary.

Results

Correlation coefficients (r) referring to the correlations between the observed phytotoxicity and the other observed variables are given by pairs in Table 1. The factor-weights (a_{ij}) are also represented in this table.

Values of "r" indicate a strict negative relation between the occurrence of phytotoxicity and the nature of seedling emergence ($r = -0.6676$). Phytotoxicity has a strict positive relation to the application level of the combination, to the amount of rain in the second ten days of June 1979 and to the estimated relative lack of stems per ha (values of "r" being $+0.5324$, $+0.5381$ and $+0.5611$, respectively).

It is interesting to note that the correlation factors of phytotoxicity to the amount of rain in the first ten days of June and the third ten days of June are negative.

Further, in Table 2 factor-weights (a_{ij}) are shown (columns I to III) which are related to the hypothetic background variables and are indicative of the role of the said background variables in influencing the variables observed (SVÁB—NAGY 1977).

The factor-weight of phytotoxicity was only considerable in column I of Table 2 ($a_{30,\ I} = +0.7357$), so it was considered unnecessary to investigate it further in columns II and III. In column I of the table, relatively high absolute numerical values of a_{ij} were also found for the following factors:

a) nature of seedling emergence (—0.6521);

b) application level of the herbicide (+0.6624);

c) amount of rain in the second ten days of June (+0.6456);

d) amount of rain in the first and third ten days in July (—0.6372 and —0.6395 respectively).

Table 1

Average values and standard deviation of the 30 variables investigated

No.	Designation of variables	Average	Scatter
1.	Soil compactness[a]	42.1	7.7
2.	pH of the soil	7.1	0.7
3.	Organic material, %	2.7	1.1
4.	P_2O_5 content of soil, mg/108 g	16.5	9.3
5.	K_2O content of soil, mg/100 g	24.8	11.0
6.	Active N-fertilizer, kg/ha	152.2	42.5
7.	Active P-fertilizer, kg/ha	133.7	91.7
8.	Active K-fertilizer, kg/ha	149.9	56.5
9.	Depth of seeding, cm	7.2	1.3
10.	Date of seeding[b]	115.5	7.2
11.	Quality of soil preparation[c]	3.8	0.7
12.	Quality of emergence[d]	2.5	0.8
13.	Date of treatment[b]	111.7	7.6
14.	Application level of herbicide, litre/ha	6.4	1.1
15.	Depth of herbicide incorporation, cm	8.7	2.2
16.	Air temperature, °C May	19.2	3.6
17.	June	22.8	2.8
18.	July	19.2	2.0
19.	Rain, mm 1st ten days of May	13.9	20.1
20.	2nd ten days of May	8.6	1.9
21.	3rd ten days of May	5.7	8.0
22.	ost ten days of June	3.3	5.0
23.	2nd ten days of June	61.8	35.6
24.	3rd ten days of June	19.1	16.4
25.	1st ten days of July	22.8	11.5
26.	2nd ten days of July	15.4	10.8
27.	3rd ten days of July	15.5	12.5
28.	Density of weed growth[e]	1.3	0.8
29.	Estimated lack of stems (1000)	10.3	8.8
30.	Degree of phytotoxicity, %	2.8	7.5

a) According to Arany
b) Days after the 1st of January
c) Rated from 5 (optimal) to 1 (poor)
d) Rated from 3 (optimal) to 1 (weak/poor)
e) Rated from 0 (very good weed killing) to 5 (total lack of weed killing)

Table 2

Correlation factors by pairs (r), between phytotoxicity and the other analysed factors, and variation in factor-weights a_{ij}

No.	Designation of variables	Values of "r"	Factor-weights		
			I	II	III
1.	Soil compactness[a]	—0.1856	—0.2051	0.5330	0.0760
2.	pH of the soil	0.2819	*0.5046*	0.0682	0.2763
3.	Organic material, %	—0.0230	0.1424	0.5626	0.4068
4.	P_2O_5 content of soil, mg/100 g	0.0734	0.3232	0.1155	0.5172
5.	K_2O content of soil, mg/100 g	—0.0526	0.0975	0.6869	0.1881
6.	Active N-fertilizer, kg/ha	—0.2402	—0.1678	—0.3636	0.4965
7.	Active P-fertilizer, kg/ha	—0.0545	0.0508	0.1426	0.1937
8.	Active K-fertilizer, kg/ha	—0.1941	0.0051	—0.3188	0.4455
9.	Depth of seeding, cm	0.3228	0.4480	0.0987	—0.0951
10.	Date of seeding[b]	—0.0053	—0.1299	—0.5209	—0.0490
11.	Quality of soil preparation[c]	0.0953	0.1024	—0.3351	0.2256
12.	Quality of emergence[d]	*—0.6676**	*—0.6521**	—0.0683	0.4362
13.	Date of treatment[b]	—0.0347	—0.2358	—0.3610	—0.2548
14.	Application level of herbicide, litre/ha	*0.5324*	*0.6624**	—0.2704	—0.1836
15.	Depth of herbicide incorporation, cm	0.0896	0.3238	—0.2409	0.3660
16.	Air temperature, °C May	—0.3122	*—0.5537*	0.3127	—0.4644
17.	June	0.1159	—0.1873	0.2891	—0.5538
18.	July	—0.1235	—0.3892	—0.0419	—0.4350
19.	Rain, mm 1st ten days of May	—0.0109	—0.0594	0.0186	0.0362
20.	2nd ten days of May	—0.1229	—0.1678	0.0946	0.2962
21.	3rd ten days of May	—0.2173	—0.0369	0.6244	0.1085
22.	1st ten days of June	—0.2222	—0.4826	—0.3321	—0.1961
23.	2nd ten days of June	*0.5381*	*0.6456**	—0.5447	—0.1082
24.	3rd ten days of June	—0.2801	—0.4434	—0.2553	0.1729
25.	1st ten days of July	—0.2862	*—0.6372**	—0.0682	—0.1810
26.	2nd ten days of July	—0.3251	—0.3670	0.1614	0.0763
27.	3rd ten days of July	—0.3387	*—0.6395**	—0.3104	0.1134
28.	Density of weed growth[e]	0.1453	0.1184	0.2670	0.0940
29.	Estimated lack of stems (1000)	0.5611	0.5465	0.1291	0.3443
30.	Degree of phytotoxicity, %	—	*0.7357*	—0.1113	—0.3988
	Self Value (λ)		4.8901	3.2859	2.7485

a, b, c, d, e: as in Table 1

* Refers to significant values (at $r_{p=5\%} = 0.5910$, as critical value)

These relatively high absolute numerical a_{ij} values may indicate the existence of some common relation among the factors these values belong to.

Not significant but important factors were, in addition, the pH value of the soil, the average temperature in May, as well as the estimated lack of stems per ha.

For estimating factor-weights the following equation was applied: $a_{ij}^2 = r_{p\%}$, in which $r_{p\%}$ stands for the critical value of the two-variable correlation factor at $p = 5\%$, and a_{ij}^2 represents the square of the individual

factor-weights. In this case the critical value of "r" (correlation coefficient) was taken (at FG $= n - 1 = 85$) as being equal to 0.3494, and from this:

$$a \geq r_{p\%}^{1/2} \geq 0.3494^{1/2} \geq 0.5910.$$

Accordingly, absolute numerical values of a_{ij} greater than 0.5910 are significant, they are consequently correlated in respect of a given factor (background variable).

Conclusions

Both the regression analysis of two variables and the factor-analysis method revealed certain factors which, under field conditions (and all of them acting simultaneously in the same period), may adversely influence the selectivity of the AD-67 plus EPTC combination (ASH-202 80 EC formulation). Weak emergence of seedlings, which may be the direct result of using low quality seeds, or may be caused indirectly by unfavourable weather, will lead to retarted plant growth, and this, in turn, will render the plant highly sensitive to any new stresses. Even a slight over-dose of a herbicide — in this case ASH-202 80 EC — may represent such a stress to the weakened culture. resulting in the occurrence of phytotoxic symptoms in individual plants, This suggestion seems to be proved through investigations on the existence of a relationship between the application level of the herbicide and the degree of phytotoxicity.

The hot, dry period lasting from the early days of May to mid-June, and the following large amount of rain (80 to 100 mm) within a short time not only caused slow growth of the plants, but almost certainly induced adverse changes in the absorption, penetration and translocation properties of the two components of the herbicide combination applied. The correlation found between the factors of rain, temperature and phytotoxicity seemed to prove this suggestion indirectly.

Results obtained via the factor-analysis method not only underlined the results obtained through regression analysis of two variables, but revealed that phytotoxicity to maize only occurred on fields or field sections where seedling emergence was poor or weak for reasons other than herbicide treatment, where local over-dose application could be established and where the most extreme climatic conditions prevailed, all these factors affecting the same area.

The main conclusion is that factors having large factor-weights in column I of Table 2 can be regarded as factors affecting the selectivity of the EPTC plus AD-67 combination (ASH-202 80 EC), taken all together as a complex factor or individually.

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RELATIONSHIP BETWEEN THE PEEL STRUCTURE AND STORABILITY OF APPLES

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In the course of investigations carried out over a period of 6 years the average thickness of the peel (size of cuticle, epidermis and hypodermis cells) when removing Jonathan and Starking apples from storage was measured with a microscope. Furthermore, the number of lenticels and stomata per m^2 of apple peel was counted, again using a microscope. These measurements were taken at the stem end, at the largest diameter and at the stylar end of the apple. Also, a record was made again over a period of 6 years, of losses due to shrinking and deterioration after 6 months of storage in unchanged air conditions and after 7.5 months of storage in a controlled atmosphere, as well as the percentage proportions of spottedness and scald, which are typical skin diseases in Jonathan apples.

Introduction

In the course of storage, differences in the losses due to deterioration and shrinking and in the percentages of skin spottedness have repeatedly been noticed, depending not only on the variety, crop year and method of storage but also on other, as yet insufficiently investigated factors.

In 1972 a series of storage experiments was set up, in which the peel structures of the apple varieties Jonathan and Starking were examined. The experiments were aimed at receiving an answer to the following questions: are there measurable differences in peel structure between the apple varieties, and if so, are they correlated in any way with storability?

Material and method

The microscope examination of apple peel structure was carried out in the Anatomica Laboratory at the Research Institute of the Wood Industry, while the storage took place in the Experimental Plant of the University of Horticulture at Szigetcsép. For the laboratory examinations 10 apples with average diameters were used from each variety. The peel structure was studied and its thickness was measured with a Zeiss research microscope at three places on the fruit: the stem end, the largest diameter and the stylar end. The samples were cut into pieces, prepared, dehydrated through an alcohol series, embedded in paraffin and excised using a microtome. The sections were then prepared and examined under a microscope, where measurements and micrographs were made. The dimensions of the cuticle, epidermis and hypodermis, i.e. the thickness of the peel, were established on the average of 100 measurements taken on each of three parallel samples (Fig. 1). The number of lenticels and stomata (Figs 2, 3) was determined on a 3×3 cm^2 area of peel at each of the measuring sites (stem end, largest diameter, stylar end) (Babos 1973).

First of all random samples were taken when the apples were stored to determine the average thickness of the peel and the number of lenticels and stomata; however, these measurements will not be presented here due to lack of space. Several series of measurements were made on Golden Delicious, too. For the sake of comparison some of these are referred to in the Results.

The varieties included in the experiment were stored under unchanged air conditions for 6 months or in a controlled environment for 7.5 months. In studying the storage loss the difference in the period of storage must definitely be taken into consideration, since in the final phase of storage losses accelerate hyperbolically (SASS 1973).

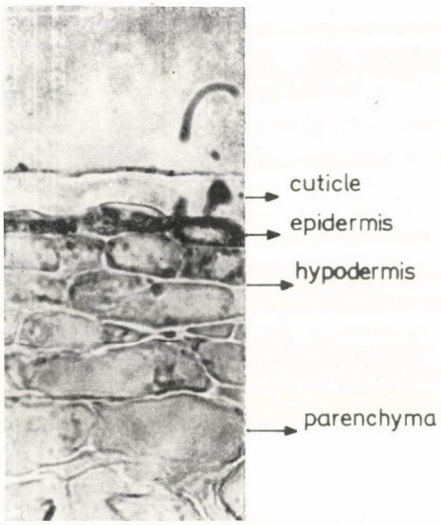

Fig. 1. Anatomy of peel along the largest perimeter on removing Jonathan apples from storage. Detail of cross-section. Microscopic photo 400×

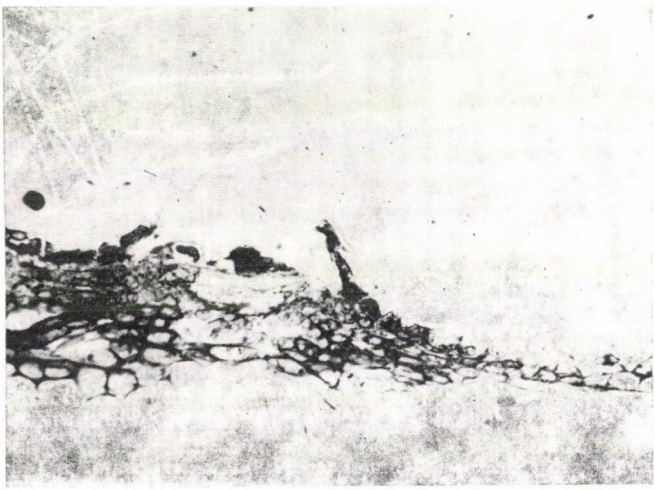

Fig. 2. Lenticel in the peel along the largest perimeter on a Golden Delicious apple at the beginning of storage. Detail of cross-section. Microscopic photo 120×

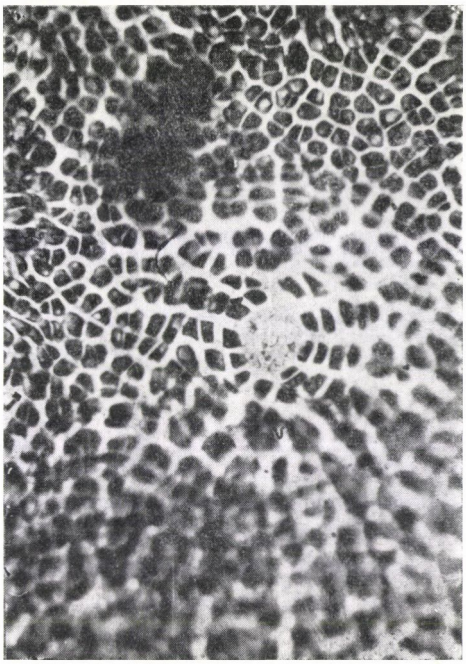

Fig. 3. Stoma in the peel at the stylar end of a Starking apple at the beginning of storage. Surface preparation. Microscopic photo 300×

The fruits were picked every year at a stage of ripening which was optimum for long storage in the Jonathan variety, and stored under conditions which were primarily designed for Jonathan apples.

The experiments carried out in 1972 and 1973 were of an informative nature, so the results are not presented here. Systematic experiments covered the 6 years from 1974 to 1979. The authors are convinced that such a long period of experimentation may bring us closer to a solution, even if the character of the experiment does not make it easy to answer the questions raised, and despite the fact that investigations of this kind are almost totally absent from the international literature.

Results

Data on the dimensions of the cells which make up the peel of Jonathan and Starking apples are presented in Table 1. The figures immediately reveal a considerable difference in the thickness of the peel, which is 28.4 μm in the variety Jonathan and 41.2 μm in Starking. Furthermore, the results show that the peel is much thinner at the stem end (Jonathan: 24.7 μm, Starking: 35.8 μm) than at the stylar end (Jonathan: 34.5 μm, Starking: 41.2 μm).

The number of lenticels and stomata was the lowest at the stem end in both apple varieties. This fact may partly explain why "Jonathan spots" are found in larger numbers at the stem ends of Jonathan apples (because

Table 1

Condition of peel structure when removing Jonathan and Starking apples from storage

Variety	Site of measurement	Cuticle	Epidermis	Hypodermis	Thickness of peel	Average thickness of peel	Lenticels	Stomata
		μm					n/cm²	
Jonathan (spindle bush)	stem end	4.65	5.52	14.56	24.73		8.0	0.0
	largest diameter	4.65	6.70	14.65	26.00	28.4	26.3	0.3
	stylar end	4.65	7.82	21.99	34.46		77.2	2.0
Starking (spindle bush)	stem end	5.58	13.98	16.24	35.80		7.3	0.0
	largest diameter	4.68	15.07	26.65	46.40	41.2	15.7	0.0
	stylar end	4.65	12.93	23.67	41.25		6.23	0.7

Note: Measurements taken on apples removed from normal storage (with unchanged air conditions) on 19th March 1974.

Table 2

Average peel thickness, number of lenticels and stomata when removing Jonathan and Starking apples from storage

Variety	Method of storage	Years						6-year average	Mean
		1974	1975	1976	1977	1978	1979		
Peel thickness (μm)									
Jonathan (spindle bush)	unchanged air	27	21	33	59	54	87	46.8	45.4
	controlled air	32	22	34	40	60	76	44.0	
Starking (spindle bush)	unchanged air	41	25	37	57	66	102	54.7	54.5
	controlled air	—	22	44	51	57	98	54.4	
Lenticels (n/cm²)									
Jonathan (spindle bush)	unchanged air	37	65	50	33	41	79	50.8	49.4
	controlled air	22	34	65	52	74	41	48.0	
Starking (spindle bush)	unchanged air	28	44	28	38	46	39	37.2	37.4
	controlled air	—	24	24	49	64	27	37.6	
Stomata (n/cm²)									
Jonathan (spindle bush)	unchanged air	2	4	4	1	4	5	3.3	3.3
	controlled air	5	2	4	3	2	4	3.3	
Starking (spindle bush)	unchanged air	1	3	2	2	2	3	2.2	2.2
	controlled air	—	1	1	2	4	3	2.2	

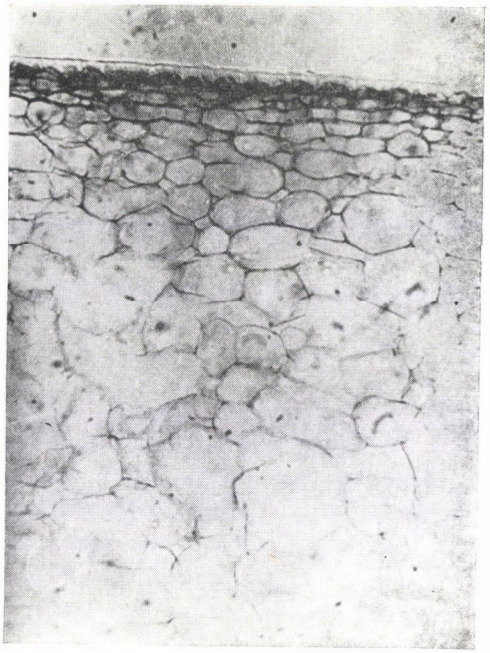

Fig. 4. Cross-section detail of peel at the stem end on removing a Jonathan apple from storage. Microscopic photo 120×

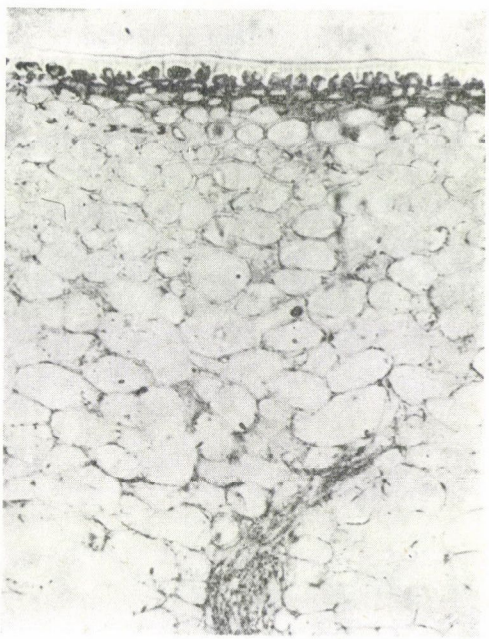

Fig. 5. Cross-section detail of peel at the stem end on removing a Starking apple from storage Microscopic photo 120×

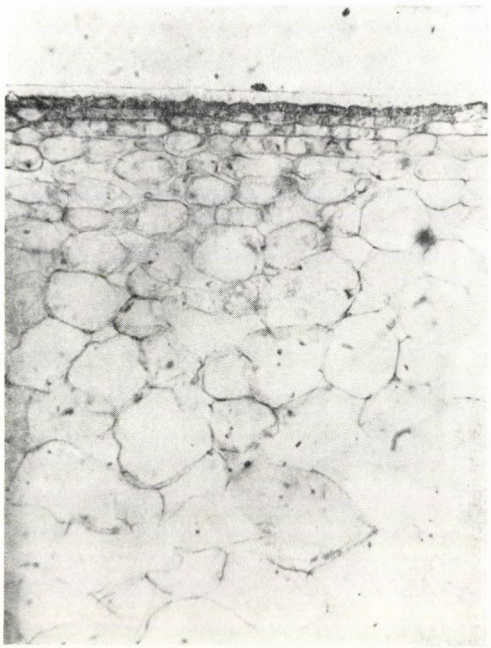

Fig. 6. Cross-section detail of peel along the largest perimeter on removing a Jonathan apple from storage. Microscopic photo 120×

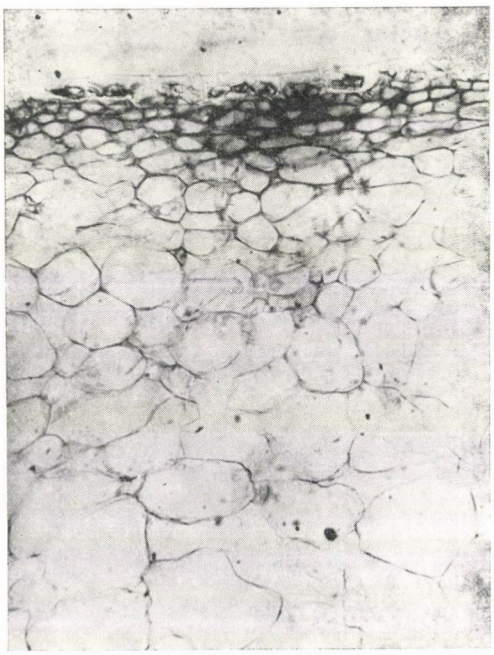

Fig. 7. Cross-section detail of peel along the largest perimeter on removing a Starking apple from storage. Microscopic photo 120×

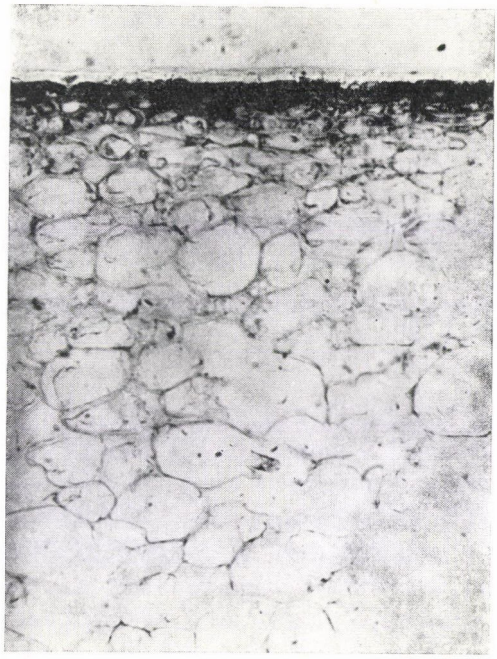

Fig. 8. Cross-section detail of peel at the stylar end on removing a Jonathan apple from storage. Microscopic photo 120×

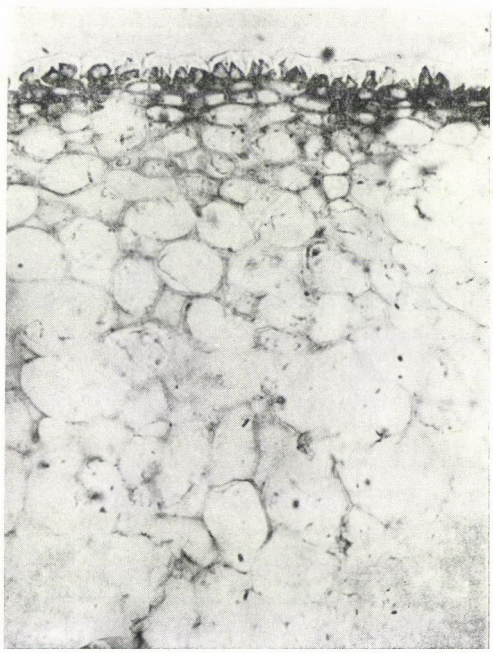

Fig. 9. Cross-section of peel at the stylar end on removing a Starking apple from storage. Microscopic photo 120×

the toxic gases arising inside the apple, which oxidize the peel in the form of small black spots, can accumulate more easily at sites where fewer lenticels and stomata are found), and why a higher rate of bitter spottedness is found at the stylar ends of Starking apples.

Microscopic photos were taken of changes in the peel structure of Jonathan and Starking apples removed from normal storage in 1978 (Figs 4—9).

Table 2 shows the average thickness of the peel and the change in the number of lenticels and stomata, not only as a function of the storage method but also as an average for the experimental years.

The data contained in Table 2 confirm the facts established on the basis of the results in Table 1. According to the average value over 6 years, Jonathan has the thinner peel (45.4 μm compared to 54.5 μm in Starking). The number of lenticels and stomata per unit surface area is considerably larger in the variety Jonathan; Starking apples have 12 less lenticels and 1.1 less stomata per unit area than Jonathan apples. This may be one of the reasons for the 5.4% verage loss due to shrinking in Jonathan compared to only 4.3% in Starking apples (Fig. 10). The deterioration in the quality of Jonathan was also greater: 2.6% compared to 1.2% in Starking. On the other hand, Jonathan spots occurred to a much lower extent (8.8%) than scald did in the variety Starking (31.7%). (Scald, however, may be substantially reduced by improved storage techniques.) When comparing the peel thickness (52.9 μm), number of lenticels (55.3/cm^2) and stomata (3/cm^2) in the variety Golden Delicious to the corresponding parameters in Starking, and considering the greater shrinkage losses known to occur in Golden Delicious, similar correlations are obtained.

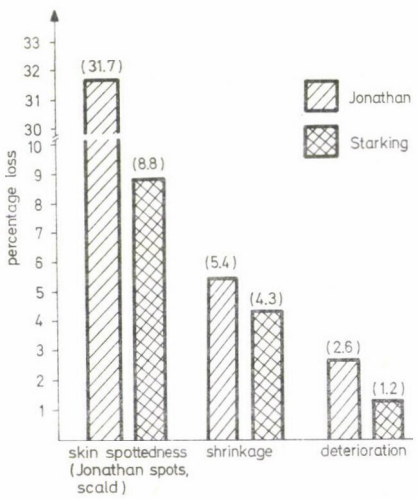

Fig. 10. Storage losses for apples (6-year average)

Table 3

Changes in the average peel thickness and number of lenticels and stomata in Jonathan and Starking apples during storage

Variety	Method of storage	Years		Average for unchanged and controlled air	
		1974–1976	1977–1979	1974–1976	1977–1979
Peel thickness (μm)					
Jonathan (spindle bush)	unchanged air	27	67	28	63
	controlled air	29	59		
Starking (spindle bush)	unchanged air	34	75	33	72
	controlled air	33	69		
Lenticels (n/cm^2)					
Jonathan (spindle bush)	unchanged air	51	51	45	53
	controlled air	40	56		
Starking (spindle bush)	unchanged air	33	41	28	44
	controlled air	24	47		
Stomata (n/cm^2)					
Jonathan (spindle bush)	unchanged air	3	3	3.5	3.0
	controlled air	4	3		
Starking (spindle bush)	unchanged air	2	2	1.5	2.5
	controlled air	1	3		

The method of storage (controlled and unchanged air conditions) does not appear to influence the thickness of the apple peel. Thus, the thinning of the peel found under air-controlled storage conditions in both apple varieties only points to the fact that the thickness of the apple peel varies even within the variety.

The 6-year data series on the average peel thickness in Table 2 shows increasing values for both varieties, so they were broken down into two groups for the periods 1974—76 and 1977—79 (Table 3).

According to the data thus obtained, the peel was considerably thicker (e.g. in Jonathan 28 μm in 1974—76, 63 μm in 1977—79), and the number of lenticels larger (e.g. in Starking 28/cm^2 in 1974—76 and 44/cm^2 in 1977—79) in the last three years of the experiment in both apple varieties. Changes in the number of stomata only showed a similar tendency in the variety Starking (1.5/cm^2 in 1974—76, 2.5/cm^2 in 1977—79). Two reasons can be offered for these changes in the thickness of the peel: either they were caused by differences in the meteorological conditions (temperature, precipitation, sunshine hours) between the two periods, or by pesticides containing copper which were used for spraying in the last three years.

Annual changes in storage losses cannot be convincingly explained by the peel structure. More reliable conclusions are likely to be drawn from a study on the correlation between annual trends in meteorological factors and the components of the apples.

Conclusions

The following conclusions can be drawn from the experiments. The apple has a thinner peel at the stem end than at the stylar end; Starking apples have thicker peels than Jonathan apples; lenticels and stomata are fewest at the stem end, larger in number at the largest diameter, and most numerous at the stylar end; the number of lenticels and stomata per unit area of peel is much lower in the variety Starking; the average peel thickness and the number of lenticels and stomata were about 100% larger in both varieties in the second half of the 6-year experiment.

Starking showed a lower rate of shrinkage loss than Jonathan over a 6-year average, and the loss due to deterioration was also smaller during the storage of Starking apples compared to Jonathan; shrinkage loss was greater in Golden Delicious than in Starking owing to the thinner peel and higher number of lenticels and stomata in the former variety; on the basis of yearly variations in storage losses no conclusions could be drawn on the condition of the peel structure or on the changes observed in it.

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VARIA I

CHANGES CAUSED BY CCC TREATMENT IN THE ENDOGENOUS GIBBERELLIN CONTENT DURING THE SWELLING OF PHASEOLUS VULGARIS L. SEEDS

The gibberellins are known to be particularly important in controlling the physiological processes of germination, as they start the de novo synthesis of the hydrolytic enzymes which mobilize the stored nutrients (YOMO—VARNER 1971, 1973). The role of conjugated gibberellins and the importance of de novo gibberellin synthesis in raising the level of free endogenous gibberellins in the early phase of germination have not, however, been clarified yet.

During the germination of seeds a decrease in the quantity of conjugated gibberellins can be observed (BARENDSE *et al.* 1968, SEMBDNER *et al.* 1968, 1972, YAMANE *et al.* 1975), which indicates their role in storage. No similarly unequivocal data are available for defining the importance of the de novo gibberellin synthesis, since the effect of the inhibitors of gibberellin biosynthesis on the germination of seeds has been found to be highly varying.

According to investigations by KHAN—TOLBERT (1966a, b) CCC (chlorocholine-chloride) at a concentration of $2.5 \cdot 10^{-3}$ mol does not influence the germination of Lactuca sativa seeds. It has no effect on the germination of tomato and bean seeds at a concentration of 1000 mg/litre either (MICHNIEWICZ *et al.* 1965).

According to the data of PRAKASH—LAL (1968) a CCC solution of 0.05% has a stimulative effect on the germination of cotton seeds, as it also has on the germination of apple seeds in all stages of stratification at a concentration of $6 \cdot 10^{-6}$ mol (HALINSKA *et al.* 1975). On the other hand, the germination of *Brassica oleracea* (KNYPL 1967), *Leptadenia pyrotechnica* (SEN—CHAWAN 1971), *Lupinus albus* (NAGY—GÖNDÖR 1977) seeds and stratified seeds of *Tilia platyphyllos* (NAGY 1980) is retarded by CCC.

On the basis of these contradictory results the importance of de novo gibberellin synthesis in the early phase of germination is very difficult to decide, the more so because in the above mentioned experiments the effect of CCC treatment on changes in the endogenous gibberellin content of the seeds was not studied.

In the present experiments changes in the endogenous gibberellin content of *Phaseolus vulgaris* "Juliska" seeds during swelling in 500 ppm CCC solution were traced. In methanol extracts prepared from the seeds at various stages of swelling the ethyl acetate-soluble fraction containing free gibberellins and the butanol-soluble fraction, in which gibberellins were contained in bound form, were separated by thin layer chromatography, as described in an earlier work (NAGY—GÖNDÖR 1977). The biological activity of the gibberellin spots was measured with the lettuce hypocotyl test (FRANKLAND—WAREING 1960). The results show changes in the endogenous gibberellin content of 25 seeds.

The quantitative changes in free gibberellins during the swelling of untreated and CCC-treated *Phaseolus vulgaris* seeds are shown in Fig. 1.

On chromatograms prepared from the extracts of control seeds swollen in distilled water for various periods, biological activity was observed in the Rf 0.1—0.3, Rf 0.6—0.8 and Rf 0.9—1.0 bands (Fig. 1A). In the same positions considerable biological activity could be measured in chromatograms prepared from the extracts of dry seeds too, which means that

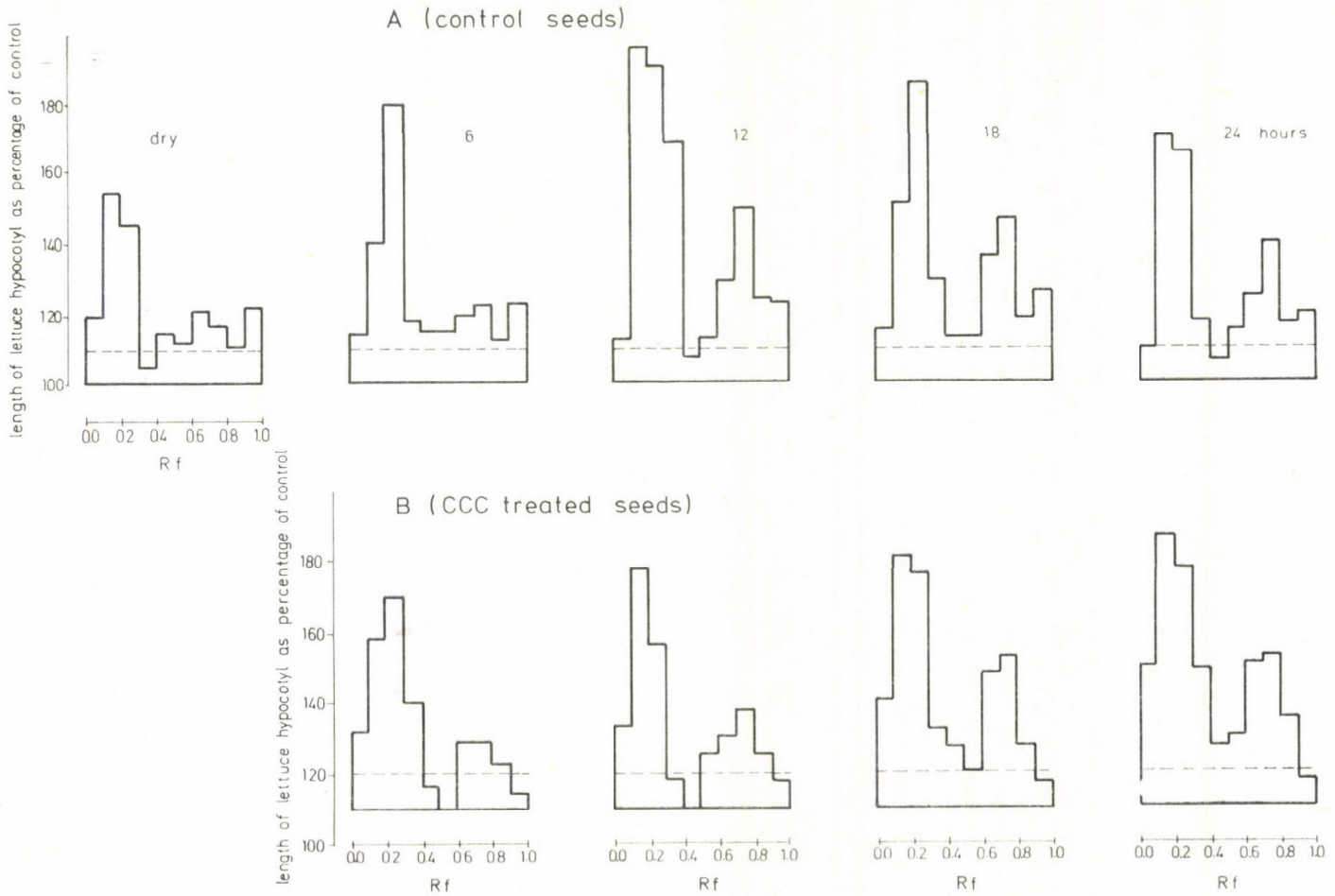

Fig. 1. Effect of CCC treatment on quantitative changes in free gibberellin-like substances in the ethyl acetate-soluble fraction during the swelling of *Phaseolus vulgaris* seeds, as shown by the biological activities of chromatogram spots

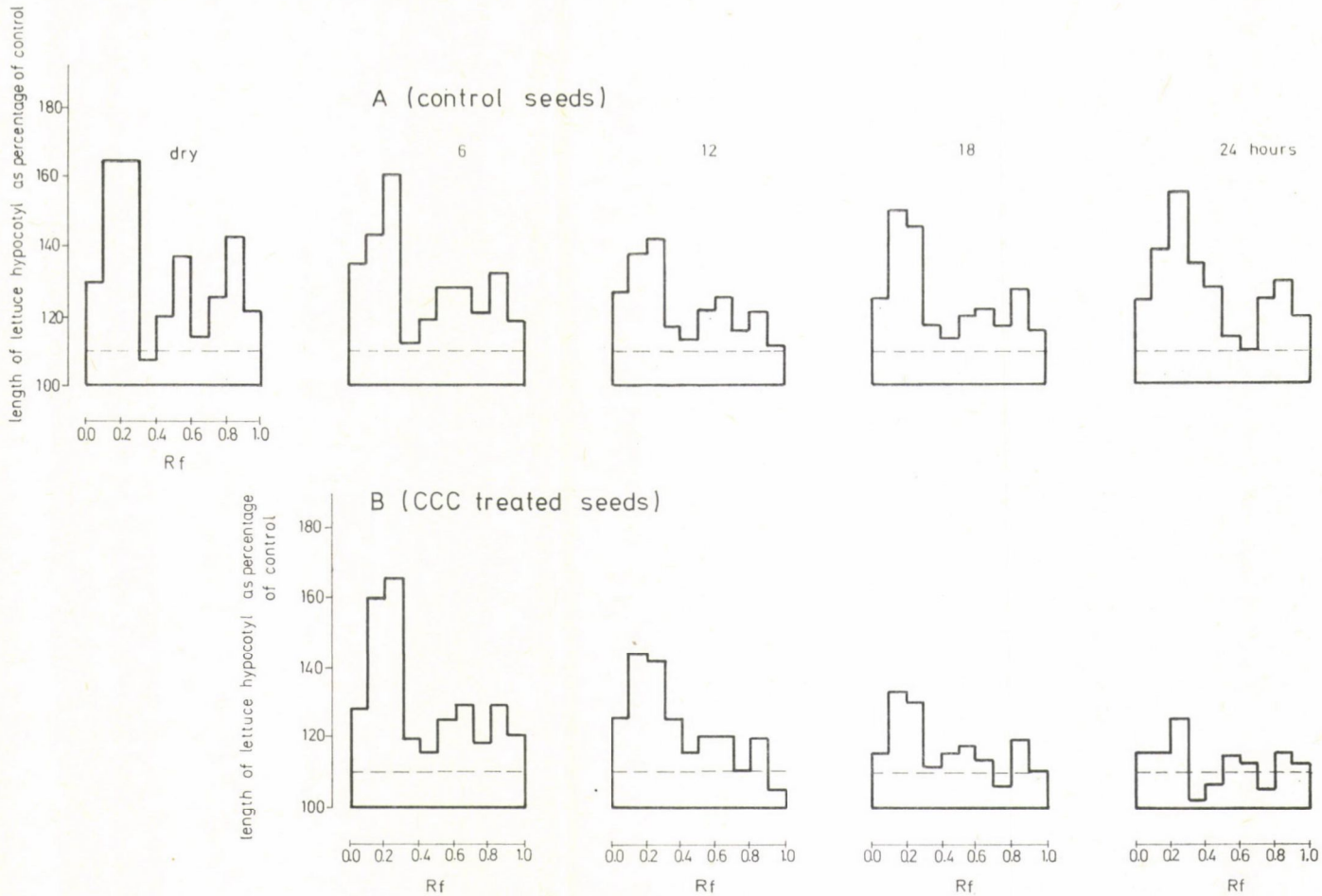

Fig. 2. Effect of CCC treatment on quantitative changes in conjugated gibberellin-like substances in the butanol-soluble fraction during the swelling of *Phaseolus vulgaris* seeds, as shown by the biological activities of chromatogram spots

in the dry seeds a certain amount of gibberellin is found in a free form. During the swelling of the seeds endogenous, free, gibberellin-like substances showed a quantitative increase, reaching a maximum in the 12th hour of swelling in all three biologically active spots. Later in the course of swelling the amount of gibberellin-like substances slightly decreased.

The extent of biological activity is not the same in all bands. The activity was found to be the highest in the Rf 0.1—0.3 band and the lowest in the Rf 0.9—1.0 band. These differences in activity between the bands do not necessarily represent quantitative differences, since the biological test gives different responses to the different gibberellins (JONES—VARNER 1967, REEVE—CROZIER 1974). Differences in biological activity within the same band, on the other hand, suggest quantitative changes.

On the basis of the results it seems that the biochemical and physiological processes of germination, as well as the normal growth of the seedlings, require definite quantities of gibberellins to be present in the successive phases of swelling. According to the maximum curve in the early phase of germination, this change can be observed not only with the gibberellins (NAGY—GÖNDÖR 1977) but also in the case of indoleacetic acid (TILLBERG 1977) and cytokinins (KOPECKY *et al.* 1975, JULIN-TEGELMAN 1979).

When seeds were treated with CCC (Fig. 1B) the gibberellin-like activity in the chromatogram spots did not follow a maximum curve, as in the control, but rose gradually until the 24th hour of swelling, though even then it did not reach the maximum observed in the control. In the case of CCC-treated seeds biological activity could not be measured in the Rf 0.9—1.0 band.

In biological tests the gibberellin conjugates show an activity different to that of the corresponding free acids (YOKOTA *et al.* 1971, SEMBDNER *et al.* 1968, 1972, 1976), the extent of which depends on the type of aglucon, the biological test and the manner of application. Treatment through the root — mainly under non-sterile conditions — results in a higher activity than treatment through the leaf, because the activity of the hydrolytic enzymes in the roots and, under non-sterile conditions, the microbial activity greatly influence the results of the biological test (REEVE—CROZIER 1974, SEMBDNER *et al.* 1972, 1976, BERNHARDT *et al.* 1979). Since the extent to which the different gibberellin conjugates are hydrolysed also varies with the biological test, their biological activity is also highly varied (GRAEBE—ROPERS 1978).

Quantitative changes in conjugated gibberellins during the swelling of untreated control and CCC-treated seeds of Phaseolus vulgaris are seen in Fig. 2.

On the chromatogram of the butanol fraction of control seeds biological active spots were found in the Rf 0.1—0.3, Rf 0.5—0.7 and Rf 0.8—0.9 positions (Fig. 2A). The Rf 0.1—0.3 spot showed a biological activity higher than that of the material in either the Rf 0.5—0.7 or the Rf 0.8—0.9 position, and the trend of the change was not the same either. In the first 12 hours of swelling the amount of conjugated gibberellins gradually decreased in all three spots; later, however, an increase in the amount of gibberellin-like compounds in the Rf 0.1—0.3 and Rf 0.8—0.9 positions, and a further gradual reduction in those in the Rf 0.5—0.7 position were observed.

On the basis of results obtained using the lettuce hypocotyl test it can be established that the quantitative changes caused by CCC-treatment in the conjugated gibberellin-like substances found in the butanol-soluble fraction also differ from those observed in the control (Fig. 2B). On the chromatogram of extracts from CCC-treated seeds the gibberellin-like activity appeared in the same bands as on the chromatogram of the control, though, in contrast to the control, it showed a gradual decrease during swelling in all three bands.

Since the CCC absorbed by the seeds entered the sample during extraction, the extent to which CCC influenced the results of the biological test, if at all, was examined. The amount of CCC taken up by the seeds was measured using a semi-quantitative method with the aid of a standard, on the basis of the colour reaction given with the Dragendorff reagent.

CCC could only be demonstrated in the butanol-soluble fraction containing conjugated gibberellins, in the Rf 0.0—0.1 position. Since in the course of chromatography the CCC remained near the start, it was only able to influence the biological test in the first band.

The possible quantities of conjugated gibberellins in the first band was calculated as GA_3 equivalent at various stages of swelling, and the extent to which the amount of CCC taken up by the seeds affected the gibberellin sensitivity of the test was examined.

The amount of CCC taken up by the seeds up to the 24th hour of swelling (14 μg/seed) reduced the sensitivity of the lettuce test by only 12%, while the amount of CCC absorbed during swelling for 6, 12 and 18 hours (0.5, 6 and 9 μg, respectively) did not influence it at all, so the CCC, which is left at the start, seems unlikely to be the casue of the reduction in gibberellin-like compounds in the butanol fraction, nor can it cause the trend of the change to be different from the control.

On the basis of results obtained with the CCC treatment of *Phaseolus vulgaris* seeds it seems that in the endogenous gibberellin maxima of untreated *Phaseolus vulgaris* seeds the de novo synthesized gibberellins also play some part. In seeds treated with CCC this synthesis apparently does not take place, which is why a maximum similar to that in the control is not reached; here the level of endogenous free gibberellins only rises through release from conjugates. In the present experiment the CCC treatment did not inhibit the germination of the seeds, and differences were found in the endogenous free dibberellin content compared to the control. This suggests that it is in the regulation of the normal growth and development of the seedling rather than in an early phase of seed germination that the gibberellin synthesis initiated during swelling has an important role.

Since the endogenous gibberellin level developed under the influence of CCC and other growth retardants is rarely correlated with the effect of growth inhibition, so that the CCC treatment sometimes has no influence on the level of endogenous gibberellins, while in other cases it raises it (Bragt 1969, Halevy—Shilo 1970, Snir—Kessler 1975), it can be supposed that in addition to influencing the biosynthesis of gibberellins the CCC must have other actions too. This is indicated by experiments in which growth inhibition induced with CCC could not be reversed by exogenous gibberellin (Crozier *et al.* 1973, Lang 1970). In other cases, however, the inhibitory effect of CCC could be reserved by applying cytokinins (Knypl 1967, Chavan—Sen 1974), which also suggests that the CCC may act at other points of the metabolism as well.

The growth retardants and the biosynthesis inhibitors of sterols have similar effects on the growth of plants (West—Fall 1972), and the sterols reverse the inhibition caused by the retardants (Douglas—Paleg 1974). These findings also show that the mode of action of CCC and other growth retardants cannot always be explained exclusively by the inhibition of gibberellin biosynthesis. The contradictory results published in the literature concerning the CCC treatments of various seeds may thus be related to differences in the responsiveness to other effects of CCC.

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RELATIONSHIP BETWEEN THE PHOTOPERIOD AND THE DIAPAUSE OF ENDOPARASITES OF ATHALIA ROSAE L.

Studies on the photoperiod-dependent diapause in the host-parasite relation started relatively late. It seems that experiments aimed at clarifying the correlation were delayed for a long time by a statement by SALT (1941) that the diapause of the endoparasites was determined exclusively by the host organism. According to SIMMONDS (1946, 1947) the coincidence of diapause in parasites and their hosts is a chance phenomenon occurring under the influence of unfavourable external factors. On the basis of her own experiments and the large number of literary data which had been published in the meantime, MASLENNIKOVA (1960) was the first to set up three groups in which the diapause of the endoparasites can be largely placed. These are:

1. The diapause of the endoparasite develops in an autonomous nanner, i.e. irrespective of the host organism.

2. The diapause of the endoparasite depends equally on the external environmental conditions and the physiological state of the host organism.

3. The diapause of the endoparasite is exclusively determined by the physiological state of the host organism.

To settle the question experiments were carried out with 3 endoparasites of *Athalia rosae* L. *(Hym.: Tenthredinidae)*.

A series of laboratory examinations were performed on host-parasite infestations using *Perilampus aeneus* Rossi *(Hym.: Chalcidiae)*. (The adult population of *P. aeneus* was raised from *Athalia rosae* larvae collected in 1977 in the environs of Keszthely.) The author was the first to demonstrate that the parasite does not place its eggs onto the bodies of the larvae but drops them scattered on the leaves of the feed plant, both on the upper and lower surface. The egg of the parasites enters the larval organism along with the food when the larva consumes the leaf after the second moult. Only one egg can enter the digestive organ of each larva. The 68 larvae thus infected were divided into two groups. One group was exposed to illumination for 13 hours (short-day) and the other for 17 hours (long-day) each day in a thermostat at 24 °C. Fifty non-infested L_3 larvae per treatment were raised parallel as a control under the same conditions. The result of the experiment was the following: infested and non-infested larvae exposed to short-day treatment remained in diapause in the eonympha phase of the cocoon stage for 5—5.5 months, while from those raised under long-day conditions the parasites emerged simultaneously with the appearance of *Athalia rosae* adults in the control. The hatching of the *Perilampus aeneus* adults lasted for 3—3.5 weeks, while that of the *Athalia rosae* adults was completed in 17 days. Mortality in the cultures was below 15%.

According to earlier investigations (SÁRINGER 1957, 1964) the host insect spends the diapause in the eonympha phase of the cocoon stage. For *Perilampus aeneus* larvae in diapause, dissection failed to establish the exact stage of development, since their ontogeny is not fully known. In the estimation of the author, the *Perilampus aeneus* larvae dissected in

diapause were in the initial phase of ontogeny. This point requires further investigation. It is planned to remove the form in diapause from the body of the original host and transplant it into that of a larva raised under long-day conditions, in order to see whether the diapause of the parasitic larva will be disturbed.

With two other parasite species, *Tachina nigricans* Egger *(Dipt.: Tachinidae)* and *Perilissus lutescens* Holmgr. *(Hym.: Ichneumonidae)*, experiments could only be carried out with simpler methods. In the fields around Balatonszentgyörgy more than 400 specimens of *Athalia rosae* larvae in the second and third stages of development were collected from an aftergrowth of rape in August 1978. On some of the larvae *Tachinida* eggs were visible even to the naked eye. The *Ichneumonidae* species places its eggs under the skin of the larva, so they cannot be seen from outside.

The larva population collected was placed in a thermostat at 24 °C, half under long-day (17/7 LD) and the other half under short-day (13/11 LD) illumination. Under long-day conditions both the infested and the non-infested larvae developed into adults, while in the short-day treatment the parasites and the *Athalia rosae* adults only appeared after 5—6 months of diapause. Mortality remained below 15% in these cultures, too. Of the larvae exposed to long-day treatment, 21.3% were infested by *Tachina nigricans* and 14.2% by *Perilissus lutescens*. The parasite population which hatched after nearly half a year of diapause in the short-day treatment showed a similar percentage of infestation.

According to the results of the experiment carried out with the above three endoparasitic species under the given experimental conditions the parasites followed the diapause of the host insect, and can thus be placed in the 3rd of the groups specified in the introduction.

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EFFECT OF AMELIORATIVE PK FERTILIZATION ON THE FERTILITY PARAMETERS OF SOME SOIL TYPES

With the multiplication of the number of state farms which belong to production systems, the demand arises to turn soils with poor productivity (soils which are badly supplied with mineral nutrients) as quickly as possible into productive, well supplied soils. Even today there exist a number of soils with an average nutrient level characteristic of the beginning of this century.

The question is: whether the soils can be made productive by simple methods, e.g. by ameliorative fertilizer doses, or whether a long period of several years is needed for this purpose? How much fertilizer is needed to raise the nutrient level of a certain soil from the

state of "badly supplied" to that of "well supplied"? Which agrochemical factors determine the efficiency of ameliorative fertilization and the conditions under which it should be applied? The present trials were aimed at obtaining an answer to these and similar questions, as in Hungary this problem has hardly been dealt with experimentally under field conditions.

Investigations with high fertilizer doses aimed at rapidly raising the nutrient level of a soil are not a novelty. The first experiments were started at the beginning of the last century when the fixation of P and K in the soil was investigated. From the middle of the fifties of the present century this experimental work became more intensive in a good many European countries. Recent publications emphasize unanimously that in order to raise the PK-supplying power of the soil the only effective way is to fertilize with extremely high doses, considerably in excess of the quantity of nutrients taken up by the plants. But the meaning of "high doses" varies considerably from one author to the other. For example, GERICKE—BÄRMANN (1963a) applied 120—180 kg P_2O_5/ha, ŠESTIĆ—DERKAČEV (1963) 180—270, KAMPRATH (1967) 340—680 and GERICKE—BÄRMANN (1963b) 600—900 kg P_2O_5/ha as maximum doses in the different treatments of their field experiments, and though they experimented on soils of different types they all reported significant after-effects which lasted for several years. As a result of a long-term experiment over 12 years SCHMITT—BRAUER (1969) found that on soils poor in P the only effective way was to use high doses of fertilizers, otherwise maximum yields could not be reached even in 10 or 12 years. At the same time they proposed that ameliorative fertilization should be carried out for a period of 3 or 4 years, after which, having reached an appropriate level of available nutrients in the soil, only 20—40% more than the P taken up by the plants should be applied in order to maintain the required nutrient level in the soil.

To study these questions, field experiments were started on typical Hungarian soils in 4 different parts of the country between the years 1973—1976. The different P and K levels of these soils were reached by using P and K doses of 0, 500 and 1000, or sometimes 1500 kg/ha P_2O_5 and K_2O, respectively. In this way it proved possible, within one experiment and one year, to obtain nutrient levels similar to those which existed in practice in various state farms. Several details of the results achieved in the above mentioned experiments were published earlier (KÁDÁR 1975, KÁDÁR *et al.* 1976; ELEK—KÁDÁR 1975, LÁSZTITY *et al.* 1978, LÁSZTITY 1977, LÁSZTITY—KÁDÁR 1978). The present paper aims to sum up the results of all the experiments, to evaluate the efficiency of ameliorative fertilization as a function of the different experimental sites, and to explain the reasons for the latter.

Description of the field experiment. As shown by the data in Table 1, the experimental plots included both light and heavy, calcareous and acid soils, poor or rich in humus. This table gives the main agrochemical characteristics of the experimental soils listed according to the character of their texture. It can be seen that as the quantity of particles smaller than 0.02 mm decreases, the sticky number according to Arany, the K-content determined by the AL-method and the hy-value of the soils also decrease. The humus content more or less follows these tendencies.

Besides the main soil properties influencing the productivity of the soils (stickiness, humus content, pH-value), the degree of P- and K-supply of these soils is also different. The fertilizer effects — as is well known — are determined above all by the degree of nutrient supply of the soils. Interpreting the AL-P- and AL-K-data of the soils, the conclusion is reached that the soils are fairly poorly supplied with P, though the soils of Kompolt and Őrbottyán approach the degree "poor to moderate", according to SARKADI (1975). The degree of K-supply on experimental sites with a heavier texture is "moderate", whilst it is "poor" on the sandy soil of Őrbottyán.

The degree of P-supply of the experimental sites, estimated by means of the Olsen-method (0.5 m $NaHCO_3$-soluble P_2O_5), differs from the above. The soils of Kompolt and

Őrbottyán (A) are supplied to a "good" or "good to moderate" degree, whilst the other experimental sites are supplied poorly on the basis of these data too. According to observations in Hungary, the effect of P-fertilizer becomes uncertain both on calcareous and on acid soils when the $NaHCO_3$-soluble P_2O_5-content of the soil reaches or surpasses 4 mg%.

The precipitation varied between 500—800 mm yearly, but differed from place to place and year to year. The climate at Nagyhörcsök represents the more arid, warmer, sunny continental climate dominating in the Hungarian Plain (Alföld), while Szilvásvárad is typical of the more humid, cooler, mountainous climate of the Northern hills (Északi-Középhegység). Kompolt and Őrbottyán represent transitions between these two types of climates.

The fertilizer treatments were different in part at the individual experimental sites, so only those which were identical at every site are dealt with here.

As fertilizers, superphosphate (18% P_2O_5), potassium chloride (40% K_2O) and calcium-ammonium nitrate (25% N) were used. The P- and K-fertilizers were applied in the autumn before ploughing, and the N-fertilizer partly in autumn and partly in spring (as top-dressing). The quantity of N-fertilizer applied in autumn varied on average between 100—300 kg/ha as a function of the previous crop and the degree of N-supply in the soil.

The test plants were winter wheat, winter and summer barley, and maize, using those varieties which are current in the agriculture of Hungary.

Ameliorative P-fertilization changed the degree of nutrient supply in every soil radically within a year. The acid soils at Kompolt and Szilvásvárad reached the category of "well to moderate supplied" with a dose of 500 kg P_2O_5/ha, and the category of "well supplied"

Table 1

Some agrochemical characteristics of the ploughed layer of the soils investigated

Soil type	Chernozem brown forest soil	Calcareous chernozem	Brown forest soil with clay illuviation	Calcareous humous sandy soil	Calcareous, poorly humous sandy soil
Experimental site	Kompolt	Nagyhörcsök	Szilvásvárad	Őrbottyán (A)	Őrbottyán (B)
Particles < 0.02 mm in %	55	40	35	10—15	10—15
Sticky number after Arany	45	36	35	28	27
hy	3.8	2.7	2.2	0.7	0 6
AL-K_2O mg%	22.4	13.6	13.5	6.2	7.2
K-supply	good	moderate	moderate	poor	poor
Humus, %	2.8	3.3	1.6	1.2	0.9
pH (H_2O)	5.8	7.7	6.7	7.1	7.5
pH (KCl)	4.9	7.2	5.8	7.0	7.2
$CaCO_3$, %	—	4.8	—	1.0	4.0
y_1	12.9	—	5.9	—	—
AL-P_2O_5, mg%	5.2	6.2	3.0	10.0	8.4
P-supply (AL)	poor	poor	poor	moderate	moderate
Olsen-P_2O_5, mg%	4.1	1.2	1.6	3.7	1.7
P-supply (Olsen)	good to moderate	poor	poor	good to moderate	poor

Table 2

Effect of a meliorative P- and K-fertilization on the AL-P and AL-K values of the soil

Treatment	Kompolt		Nagyhörcsök		Szilvás-várad	Őrbottyán (A)		Őrbottyán (B)	
	1975	1976	1974	1976	1976	1976	1977	1975	1977
				AL-P_2O_5 mg%					
P_0K_0	5.4	4.9	5.8	6.5	3.0	10.0	10.0	9.2	7.7
$P_{500}K_{500}$	11.7	8.6	19.0	12.3	9.6	16.0	16.6	21.9	14.0
$P_{1000}K_{1000}$	19.8	18.2	36.1	19.0	17.1	20.3	19.0	24.4	19.1
$LSD_{5\%}$	5.8	6.0	4.9	2.2	2.3	4.4	4.8	9.2	7.6
				AL-K_2O mg%					
P_0K_0	22.2	22.7	12.8	14.3	13.5	5.6	6.9	7.3	7.2
$P_{500}K_{500}$	26.6	24.0	19.2	17.8	17.8	9.0	10.7	11.2	9.7
$P_{1000}K_{1000}$	31.3	30.0	28.5	21.2	22.6	12.4	10.9	13.5	12.6
$LSD_{5\%}$	2.7	4.2	1.9	1.4	2.9	0.8	1.6	1.9	2.4

with a dose of 1000 kg P_2O_5/ha. The P supply of the calcareous soils rose by one category on the nutrient supply-scale with each dose of 500 kg P_2O_5/ha (Table 2).

The P-fertilizer applied to the soil interacts with the solid phases of the soil. This process has been fairly well clarified and described in soil chemistry literature. As is well known, in calcareous soils the fractions of adsorbed P and of variously soluble Ca-phosphates play the most important role, whilst in acid soils the fractions of Al-phosphate and Fe-phosphate are dominant. Studies dealing with this subject in connection with Hungarian soils have proved and confirmed previous knowledge on this problem (FÜLEKY 1975, FÜLEKY—KÁDÁR 1975).

On the above considerations, the colloidal conditions, the texture and the reaction state of the soil are of great importance in the degradation process of P-fertilizer in the soil. At the same time, the fixation of phosphorus in the soil is a long-term process, so it can only be studied by observations over a relatively long period. The theory of ameliorative fertilization is also based upon the experience that fertilizer-P introduced into the soil increases the quantity of easily soluble phosphorus in the soil, and the conditions caused by this process can be maintained for quite a long time. According to PECK *et al.* (1971) the quantity of available P in the soil is directly proportional to the quantity of fertilizer used. SHELTON—COLEMAN (1968) point out that the conditions caused by fertilizing with high P-doses remain for a long time (for years or even for decades) and only when this period has passed does an equilibrium in the P-status of the soil come into being. Consequently the easily soluble P-forms (fractions) may be present permanently.

It can be determined from the experiments that in order to increase the AL-soluble P_2O_5-content of the soils by 1 mg%, on average 70 kg P_2O_5/ha P-fertilizer was needed both for calcareous and for acid soils in the 1—3 years following the fertilization. Taking the ploughed layer to contain 3—4 million kg soil/ha on average, a dose of 30—40 kg P/ha should theoretically result in an increase of 1 mg% AL-P. Thus, approximately half the P-content

of the applied fertilizer could be detected in AL-soluble form while the other half — not detected by this method — entered other fractions of the soil.

But there was also an effect of the successive years. In the first year after the fertilization the AL-P- and K-values were higher, though the specific fertilizer-demand was 25—30% lower than in the following years. Hence, the P-status of the soils has not yet become equilibrated. This was especially significant in the case of humous calcareous chernozems, where the total P-content of the fertilizer applied remained in AL-soluble form in the first year. Thus, using this method no P-fixation could be determined in these soils. This explains the fact that on the average of the years and the experimental sites the P-fixation was less and the specific P-demand was lower for the heavier soils.

The degree of K-supply in the untreated (control) soils was "moderate", while that of the sandy soils was "poor". These categories could only be raised by one degree when a dose of 1000 kg K_2O/ha was applied. To increase the degree of K-supply in these soils to the same extent as for P, almost double the quantity of K-fertilizer would be needed. This is also indicated by the specific indices of K-fertilizer demand. K is a more mobile nutrient than P; the reactions between the AL-soluble and insoluble forms take place more rapidly in the soils, or the element soon becomes fixed in the crystal-lattice.

From the soil test data it can be concluded that the grain yield of cereals could be influenced by P-fertilization. The grain yield surpluses obtained as a result of ameliorative P- and K-fertilization mainly represent the effect of P-fertilizer. A similar picture is shown by plant analysis data, according to which the easily soluble K-content of the soils was enough to cover the moderate K-demand of the cereals.

The soil test data, particularly the data gained by the Olsen-method, and the plant analysis data showed the soils of two experimental sites to be supplied well to moderately

Table 3

Effect of P- and K-fertilization on the grain yield of cereals as a function of the degree of P-supply to the soils (t/ha)

Experimental site	Year	P_0K_0	$P_{500}K_{500}$	$P_{1000}K_{1000}$	$LSD_{5\%}$
Soil supplied with P well to moderately					
Őrbottyán (A)	1976/77	3.41	4.18	4.32	0.80
Kompolt	1975/76	4.31	4.56	4.70	0.30
Average		3.86	4.37	4.51	
Surplus yield compared to control plots		—	0.51	0.65	
%		100.0	113.2	116.8	
Soil supplied poorly with P					
Őrbottyán (B)	1976/77	2.62	2.82	3.38	0.72
Nagyhörcsök	1974/76	4.09	5.66	5.68	0.15
Szilvásvárad	1976	1.61	3.78	4.52	0.56
Average		2.77	4.09	4.53	
Surplus yield compared to control plots		—	1.32	1.76	
%		100.0	147.7	163.5	

Table 4

Effect of P- and K-fertilization with low and high (ameliorative) doses on the grain yield of cereals (on N-fertilizer basis)

P_2O_5	K_2O	Kompolt 1975/76		Őrbottyán (A) 1976/77		Nagyhörcsök 1975		Szilvásvárad 1976	
kg/ha									
Treatment		t/ha	%	t/ha	%	t/ha	%	t/ha	%
—	—	4.31	108.0	3.41	100.0	3.54	100.0	1.61	100.0
50	100	4.68		4.35		4.68		2.90	
100	200	4.62		4.13		5.16		3.12	
Mean (x_1)		4.65	107.9	4.24	124.3	4.92	139.0	3.06	190.1
500	500	4.56		4.18		5.40		3.78	
1000	1000	4.70		4.32		5.46		4.52	
Mean (x_2)		4.63	107.4	4.25	124.6	5.43	153.4	4.15	257.8
$LSD_{5\%}$		0.30		0.80		0.30		0.56	
(x_2) — (x_1)		—0.02	—0.5	+0.01	+0.3	+0.51	+14.4	+1.09	+67.7

with P, while the soils of all the other sites were poor in P. On soils which were better supplied with nutrients, joint PK-fertilization with ameliorative doses resulted in a grain yield surplus of only 0.5—0.6 t/ha and this value was hardly significant, whereas soils supplied only poorly with P produced an annual grain yield surplus of 1.3—1.8 t/ha. On the poorly humous sandy soil of Őrbottyán the yield was limited by other factors than fertilization (mainly by the drought caused by the bad water management of this soil). In Nagyhörcsök the yield surplus of 1.5 t/ha was highly significant, while in Szilvásvárad not only the first, but also the second ameliorative PK-fertilizer dose increased the yield significantly and resulted in a total grain yield surplus of 2.91 t/ha as against the yield of the control treatment. This latter increase represents 280% of the yield obtained on the untreated (control) plots (Table 3).

Thus, large ameliorative doses of fertilizer can be expected to be effective in cases where the soil is very poorly supplied with one or other of the nutrients and where factors other than the nutrient supply do not limit the achievement of high yields. To examine this problem from another point of view, when is the use of ameliorative fertilization more reasonable than that of the lower doses commonly applied? In Table 4 the effect of the lower $P_{50}K_{100}$ and $P_{100}K_{200}$-doses is compared with that of the higher $P_{500}K_{500}$ and $P_{1000}K_{1000}$-doses. Making a comparison between the two fertilizer levels used it can be seen that the higher, ameliorative doses resulted in approximately the same yields as the lower doses on the soils of Kompolt and Őrbottyán (A) which were better supplied with P. However, on the poorly supplied soil of Nagyhörcsök, and especially at Szilvásvárad, ameliorative fertilization showed an advantageous and statistically provable effect. Thus, if the method of ameliorative fertilization is not made use of, a loss of about 0.5 t/ha grain yield can be expected at Nagyhörcsök and about 1.0—1.1 t/ha at Szilvásvárad.

If the efficiency of ameliorative fertilization is to be correctly viewed other problems also have to be examined. If it is accepted that about 3 kg of wheat grain yield surplus pays for the consumption of 1 kg P_2O_5, then the dose of 1000 kg P_2O_5/ha used at Szilvásvárad will be repaid by the 2.9 t/ha grain yield surplus even in the first year. However, in the case

of ameliorative fertilization — similar to that of liming — the treatment applied to the soil is aimed at raising the nutrient status and the productivity of the soil for a period longer than one year. The expenses of ameliorative fertilization can, therefore, be divided over several years, particularly as a significant after-effect is also expected. The dose of 1000 kg P_2O_5/ha of the more expensive P-fertilizer would be repaid at Szilvásvárad in the first year, at Nagyhörcsök in the 2nd—3rd year, in Őrbottyán on soil (A) in the 3rd—4th year and in Kompolt not until the 7th—8th year. In addition, experience shows that the effects of fertilizing increase from one year to the next because on soils without fertilization the yields generally decrease more rapidly than on fertilized areas as a result of the after-effect of such high doses.

It cannot be left out of consideration that under the economical conditions of the present production systems the production of wheat only pays if the yield is over 4.0 t/ha. wield surpluses above this quantity, caused by ameliorative fertilization, will definitely improve the production cost indices, and the level of management efficiency. Therefore, the proportion of 1 kg P_2O_5 to 3 kg wheat grain yield surplus can only be one of the criteria when judging the efficiency of fertilization.

At the same time, intensive, one-sided fertilization with macro-nutrients may change the uptake of other elements by the plant, e.g. that of micro-nutrients. On calcareous soils, where the uptake of most of the micro-nutrients is restricted anyway, one-sided P-fertilization restrained the uptake of Fe and especially that of Zn, thus resulting in a yield decrease in Zn-demanding maize. For example, in maize plants at the 6-leaf stage the P/Zn proportion increased from about 100 — which is regarded as advantageous according to the literature — to 288. A similar tendency could be observed in the grain yield (Table 5).

While this decrease in the Zn-content and the shift in the P/Zn proportion could not be proved to decrease the yield of maize plants at the 6-leaf stage, these factors caused a loss of 1.0—1.5 t/ha in the grain yield, which could not be corrected even by the positive effect of K-fertilization (Tables 5 and 6).

In the years 1973—1976 the efficiency of ameliorative P- and K-fertilization was studied on five typical Hungarian soils situated in different parts of the country. The texture, the lime and humus content, as well as the degree of P- and K-supply to the investigated soils were different. At the experimental sites 0, 500, 1000, and sometimes 1500 kg/ha P_2O_5 and K_2O were applied as ameliorative fertilization. In later years the after-effects of these doses were observed. The conclusions can be summed up as follows:

On both the calcareous and the acid soils the degree of AL-P-supply rose by one category after the application of 500 kg/ha P_2O_5. To raise the AL-P-content of the soils by 1 mg% 70 kg/ha P-fertilizer was needed; thus, in the first years following the fertilization, on average half the applied P-quantity could be detected in AL-soluble form.

When considering the fixation of P in the soils it was observed that the specific fertilizer dose needed to raise the AL-P-value by one unit was lowest in the first year after the fertilization, especially on calcareous, humous, loamy chernozem soils. Both on calcareous and on acid soils only the dose of 1000 kg/ha K_2O was able to increase the degree of AL-K-supply by one category. To raise the degree of K-supply in the soils to the same extent as for the less mobile P, nearly double the fertilizer quantity was needed. The state of equilibrium has not yet been reached in the first year after the fertilization, especially in the more humous, calcareous chernozem soil, where the quantity of AL-soluble K decreased by half from the first to the third year.

The moderate K-demand of cereals could be covered by all the soils investigated. But maize, which has a higher K requirement, showed symptoms of K-deficiency even on the heavier chernozem soil, and this could only be eliminated by the first, or in some places by the second dose of ameliorative K fertilization. The ameliorative P- and K-fertilization resulted in P-effects with the cereals and in P- and K-effects with maize.

Table 5

Effect of ameliorative P-fertilization on the yield, the P- and Zn-content, and the P/Zn proportion of maize
(Calcareous chernozem, Nagyhörcsök, 1976)

Treatment	P_0	P_{500}	P_{1000}	P_{1500}	$LSD_{5\%}$
AL-P_2O_5, mg%	6.5	12.3	19.0	29.0	2.2
at the 6-leaf stage:					
P%	0.31	0.47	0.51	0.60	0.04
Zn, ppm	30.5	21.2	21.8	20.8	*2.1*
P/Zn proportion	101.6	221.7	233.9	288.5	
Yield, g/20 plants	21.0	28.0	30.0	30.0	2.4
grain yield:					
P%	0.29	0.42	0.45	0.44	0.08
Zn, ppm	34.3	23.2	23.0	20.9	*2.4*
P/Zn proportion	84.5	181.0	195.7	210.5	
Grain yield, t/ha	4.74	5.62	4.87	4.25	2.7

Table 6

Effect of ameliorative P- and K-fertilization on the grain yield
(Calcareous chernozem, Nagyhörcsök)

Treatment	P_0	P_{500}	P_{1000}	P_{1500}	$LSD_{5\%}$	Mean
Maize, grain t/ha, 1976						
K_0	4.12	4.49	4.28	3.35		4.06
K_{500}	4.94	5.72	4.82	4.58	0.55	5.02
K_{1000}	4.84	6.17	5.42	4.48		5.23
K_{1500}	5.05	6.16	4.96	4.60		5.19
Mean	4.74	5.62	4.87	4.25	0.27	4.87

The agrochemical reason for the application of ameliorative PK-fertilization is the degree of nutrient supply in the soils. As proved by the yield surpluses, the doses of ameliorative fertilization may be economical and repaid within a few years, while on better-supplied soils the preservation of the nutrient status of the soils must be kept in view and the quantity of nutrients taken up by the plants can be fed back by using lower fertilizer doses.

At the same time, ameliorative fertilization with high fertilizer doses endangers the productivity of the soil. On calcareous soils where the quantity of micro-nutrients is limited anyway, it may induce symptoms of nutrient deficiency. For example, on calcareous cher-

nozem soil, where the AL-P-value was 15—20 mg% P_2O_5, the Zn-content of the plants decreased and the optimal P/Zn proportion shifted to such an extent that these factors resulted in a grain yield loss of 1.0—1.5 t/ha in the case of Zn-demanding maize.

In order to determine the necessity of applying ameliorative P- and K-doses on a given soil, we must know the degree of P- and K-supply of the soil. The conditions of micronutrient supply must also be taken into consideration and, if necessary, the P-fertilization must be complemented by Zn-fertilization. If the information gained from soil and plant analyses do not give a clear-cut answer, it is necessary to carry out field experiments too.

*

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CHANGES IN SOME STANDARD CHARACTERISTICS OF CATTLE IN RESPONSE TO VARIOUS EXTENTS OF INBREEDING

Inbreeding is not a new procedure in the history of animal husbandry. It was already used in the last century by the great pioneers of animal husbandry; Bakewell, Colling, Orlov, Oltmans and Köppe, who produced the breeds which formed the basis for the culture breeds.

Although the importance of inbreeding in animal breeding has never been denied, it was previously applied mainly on an empirical basis.

Since the science of genetics has developed and the laws of population genetics have been established the theoretical basis of inbreeding has been clarified and inbreeding itself has been given a new interpretation.

Although the significance of inbreeding as an important method of animal breeding has not lessened, in some respects it is now seen in a new light.

In modern animal husbandry, including in ever greater measure cattle breeding, the following questions have come into prominence:

1. Whether the introduction of artificial insemination and the deep-freezing of sperm will increase the danger of inbreeding depression caused by badly planned inbreeding, and if so to what extent. It may also be of interest to examine the extent of risk involved due to the occurrence of lethal or sublethal genes in the course of artificial insemination.

2. The introduction of large-scale animal husbandry also means that the cattle stock must meet various demands:

a) a farming system involving large concentrated stocks requires increased phenotypic uniformity, which can only be expected from stocks with greater genetic homogeneity.

b) as the husbandry system becomes more and more different from the natural way of keeping animals, the question arises of how stocks approaching the homozygous state will be able to adapt themselves to the unnatural conditions.

3. In cattle breeding, as in other branches of animal husbandry, the need to produce inbred lines will sooner or later arise. The question is, whether the topcrossing of inbred males with non-inbred females, or the combination of lines with outstanding productivity in order to induce the heterosis effect, are promising methods in cattle breeding.

The experience gained in cattle inbreeding has been widely discussed for some decades. can be expected to arise in the next few decades.

In addition to basic research on the species, however, it seems to be necessary to establish facts concerning the individual cattle breeds as well. Due to such considerations, an experiment was begun in 1965 with the Hungarian Spotted breed in order to study the effects of cattle inbreeding from the point of view of the objectives outlined above.

The terms "inbreeding" and "sibbing" are not used uniformly by animal breeders. One reason for this is that animal breeders have adopted many genetic concepts from plant breeders. Plant geneticists are not generally compelled in their work to make a distinction between inbreeding and sibbing. Hardly any distinction is made between these two concepts when they are used in animal husbandry, and in cattle breeding especially they are often mixed up. "Inbreeding" was earlier regarded as a form of "pure-blood" breeding (SCHANDL 1952). According to WELLMANN (1926) inbreeding occurs when animals in a stock of restricted number (strain, herd, etc.) are bred among themselves without animals from outside being used for breeding.

In the interpretation of HORN (1963) and PIRCHNER (1964) inbreeding is a procedure whereby the animals mated are in closer relation to one another than usual (e.g. within a breed).

The latter author does not, however, make any distinction between sibbing and inbreeding. In animal husbandry a moderate degree of sibbing is generally meant by inbreeding.

Nevertheless, more exact definitions are also encountered. According to JOHANSSON—LUSH (1959) inbred lines arise when the degree of sibbing (expressed by Wright's coefficient, which will be presented later) reaches or exceeds a value of 37.5%.

At the beginning of the current work the following definition was given for the two methods of breeding: inbreeding is a procedure whereby animals are mated within a population without the introduction of fresh blood. After some time, depending on the size of the stock, when mating animals related to one another is unavoidable, this method of breeding may lead to sibbing.

Inbreeding may thus include a certain degree of sibbing but is not necessarily a criterion for it (GUBA—WOLF 1969). Today, with the introduction of artificial insemination, the multiplication of smaller or larger closed cattle stocks without using "alien" bulls is no longer possible. Therefore, inbreeding in the strict sense of the word can — in our opinion — be hardly spoken of, especially for cattle.

By systematic inbreeding, the procedure of mating animals which are related to one another with a view to producing the desired progeny is understood.

According to SCHANDL (1952) "inbreeding" means that the animals mated have the same individual among their ancestors within five generations. The inbreeding can be close (or "incestuous"), medium or moderate, depending on how distant the common ancestors in the ancestor lines of the mated animals are.

Naturally, such broad definitions can only be of an informative character. But this is all which is required in practice. In scientific papers, however, there is a justified demand to be able to express the degree of relationship, or of inbreeding, numerically. Today the most widely used formula for calculating the degree of inbreeding is the one given by Wright:

$$F_X = [\Sigma 1/2^{n_1+n_2+1} \cdot (1 + F_A)]$$

where F_X = the degree of inbreeding of the animal concerned (inbreeding coefficient),
n^1 and n^2 = the position (distance) of the common ancestor in the maternal and paternal lines, respectively,
+1 exponent = the progeny is one generation removed from the common ancestor,
F_A = the degree of inbreeding of the common ancestor if it was inbred itself.

According to this calculation, for example, when own blood males and females are mated 25.0% inbred progenies are obtained, and when first cousins are mated this figure is 6.25%. Less known methods elaborated by other authors give results similar to Wright's coefficient, such as the methods of Malécot, Dőring, Walter, etc. Whatever method is used to calculate the degree of inbreeding, the coefficient expresses the probability of two genes at one locus of the individual being genetically identical. The degree of inbreeding may refer to

Without giving further details it is easy to see that the final result of mating animals related to one another is a reduction in the number of heterozygous gene loci.

According to present knowledge the reduction in the number of heterozygous gene loci is in causal relation with inbreeding depression. As is well known, the breeding system discussed may, under certain conditions, have a deleterious effect, the phenomenon called inbreeding depression. However, no common stand has been taken so far in the relevant literature on the question of when depression occurs in consequence of inbreeding and what the causes of the injuries produced are.

The experiment which is the subject of this paper was started in 1965. There were several circumstances that gave additional motives for starting investigations into the subject. The progeny tests first organized a few years earlier called attention to the importance of matings designed to "produce" bulls with an improving effect. At that time less sperm was

imported than it is today; in planning breeding care had to be taken to produce a sufficient number of "free lines" — unrelated to each other — for the purpose of pure-blood breeding.

On the basis of previous experience in cattle inbreeding (GUBA 1957) systematic inbreeding was thought to be a suitable method both for planning specific matings and for developing new "free" blood lines.

The purpose of inbreeding was to develop a breeding system by means of which bulls with transmissible standard characteristics and new "free blood lines" could be produced.

To achieve this aim excellent cow families were chosen for the initial inbreeding. In addition to the observations discussed above, which are of immediate use in cattle breeding, other questions also proved worth investigating:

- the frequency of lethal factors in the Hungarian Spotted breed,
- the response of cattle, and of the Hungarian Spotted breed in particular, to various degrees of inbreeding,
- which characteristics are subjected to a higher degree of depression,
- what extent of phenotypic variation in the major standard features can be expected in the progeny of an inbred bull.

The cow families were chosen with the following aspects in view:

- the milk and butterfat production should be far above the average for the breed;
- there should be at least five members of the cow family living and producing milk;
- each member of the family should be characterized as far as possible by a strong physique and good constitution.

The requirements were fulfilled by the following cow families:

In experimental farm "A" in 1965:

the family of 196 Tulipán with 13 productive members
the family of 651 Duckó with 7 productive members
the family of 581 Csöngős with 9 productive members
the family of 142 Címer with 7 productive members

In 1970 the following addition was made: the family of 694 Piros with 11 productive members and in 1973:

the family of 313 Galamb with 6 productive members
the family of 178 Gerle with 8 productive members

i.e. a total of 7 families consisting of 61 animals in all.

In experimental farm "B" in 1970:

the family of 384 Szöcske with 7 productive members
the family of 298 Álmos with 6 productive members

i.e. a total of 2 families with 13 members altogether.

From each of the above listed families one bull — the progeny of a bull-raising cow — was chosen, with which all the members of the family were inseminated. The progeny were thus inbred to various degrees ($F_x = 0.03-0.25$). For the progeny derived by mating relatives the following data were recorded:

a) body measurements and live weight
   - at birth,
   - at 6 months and
   - at 12 months, to characterize the rate of growth and development;

b) diseases occurring in young animals, and causes of death where relevant;

c) milk production of heifers used in breeding;

Table 1

Effect of inbreeding on the body measurements

Number of animals	Schönmuth–Kirst (1968) German Black Spotted cattle					
	3 months		6 months		12 months	
	of age					
	23					
	A	B	A	B	A	B
Body weight, kg	88.2	89.1	185.4	192	363.7	385.9
Height of withers, cm	81	83	99	99	115	116
Depth of withers, cm	35	36	46	47	58	59
Width of withers, cm	20	20	28	28	32	38
Girth, cm	95	99	127	131	163	167
Length of trunk, cm	83	84	104	109	128	129
Hindquarters I, cm	22	23	31	32	40	42
Hindquarters II, cm	26	27	34	36	44	45
Length of hindquarters, cm	27	28	35	36	43	54
Shank circumference, cm	13	12.8	15.5	16	19	12.5

Note: A = experimental
B = control

d) fattening and slaughter results of male progeny utilized as beef cattle. The slaughtering data were obtained by the trial slaughtering of 10 fattened inbred bulls.

e) The progeny of 2 inbred bulls subjected to a progeny test carried out by the National Inspectorate of Breeding Animals and of 1 bull inbred to a high degree were studied under farm conditions.

The origin of the new-born calves was checked in each case by blood-typing. None of the progeny had to be excluded from the experiment because of uncertain origin.

In following the growth and development of the experimental animals, calves of the same sex originating from cows the same age as the experimental cows in the same farm were used as a control. The control animals were of mixed paternal origin. When examining the progeny of inbred bulls (10/7 Lottó) the control consisted in one case of cows of mixed paternal origin of the same age and from the same shed as the experimental cows. In three other cases the evaluation was carried out at a central progeny testing station on the basis of standard controls.

In examining the frequency of lethal and sublethal factors 60% of the progeny of each of 4 bulls: 1041 Párta, 1038 Kunó, 1375 Pálma and 1438 Apacs, which had been brought to the progeny testing station in order to establish their breeding value, were fertilized by their fathers, and the rest (40%) by unrelated bulls. The progeny calved were examined for vitality, growth and development. (The observations were made as described in points *a)* and *b)*.) Since the bull 1438 Apacs was found to possess a lethal factor, its progeny were examined for vitality in another farm, in comparison with the progenies of other bulls born in the farm.

Data collected as described above provided a basis for deciding what response the cattle species (particularly the Hungarian Spotted breed) gave to various degrees of inbreeding.

of animals of different age and live weight

Liebenberg—Beckert (1968) German Black Spotted cattle				Authors' own data Hungarian Spotted cattle					
70 kg		410 kg		at birth		6 months		12 months	
						of age			
13				171	64	163	57	144	42
A	B	A	B	A	B	A	B	A	B
70	70	410	410	34	180	180		376	
76.6	76.3	118	119	76	76	98	98	117	114
32.2	31.2	60	59.3	31	31	46	46	58	55
18.1	17.3	41	39.5	18	18	29	30	39	38
91.5	89.6	171	169.6	83	82	126	131	168	158
74.4	73.3	130	129.5	71	73	105	108	135	127
19.3	18.0	42	41.6	20	19	31	31	42	40
24.0	23.3	46.8	46.3	22	23	34	34	44	41
—	—	—	—	24	24	35	36	45	44
12.0	20.3	19.3							

No significant difference in average values was found between the groups.

The data were grouped according to sex and degree of inbreeding, and the effect of inbreeding, as well as the interaction of inbreeding and sex, were determined by means of multivariable variance analysis.

Due to various difficulties which arose over the years, the experiment could not be carried out according to the original plan. Consequently, the experiment had to be terminated in 1978, earlier than originally planned. Therefore, it was impossible to obtain answers to all the questions intended for investigation. However, in the meantime the number of studies carried out abroad has increased so much that reliable results can be expected by comparing the data with those obtained from foreign experiments which were carried out practically parallel to the Hungarian studies. Thus, while processing and systemizing the data continuous comparisons were made with results published abroad over the same period. It was thus possible to obtain answers to the questions outlined at the beginning of the experiment. The main object was to analyse in detail the changes caused by inbreeding in the characteristics of the progeny.

I. Effect of inbreeding on live weight and body measurements

The body measurements and live weights of the experimental calves were taken at birth and at the age of 6 and 12 months, and were evaluated in comparison with the corresponding data for the control. The body measurements are presented in Table 1, together with the data of Schönmuth—Kirst (1968) and Liebenberg—Beckert (1968). The data in the table reveal the extremely varying nature of the inbreeding depression. The correlation between inbreeding and depression is shown in Table 2.

Table 2

Coefficient of correlations between the degree of inbreeding and various body measurements

	n	Average degree of inbreeding (F%)	Girth	Depth of chest	Length of body	Height of withers	Authors and breed
At birth	99	7.8	—0.20	—0.12	—0.20	—0.18	Authors' own data
6 months	84	6.7	—0.22	—0.12	—0.21	—0.20	Hungarian Spotted cattle
12 months	65	4.0	—0.10	—0.07	—0.18	—0.19	
6 months	940	10.9	—0.11	—0.05	—0.10	—0.09	YOUNG et al. (1969)
12 months	909	10.8	—0.16	—0.06	—0.13	—0.09	Holstein-Friesian (Iowa)
3 months	860	3.4	—0.07	—0.02	—0.05	—0.09	YOUNG et al. (1969)
6 months	831	3.4	—0.09	—0.04	—0.09	—0.09	Holstein-Friesian (Ohio)
12 months	802	3.4	—0.15	—0.05	—0.07	—0.10	
6 months	78	10.2		—0.04	—0.08	—0.07	THOMSON—FREEMAN (1967)
12 months	78	10.2		—0.05	—0.10	—0.07	Holstein-Friesian (Iowa)
6 months	554	12.5				—0.18	SUTHERLAND *et al.* (1962) Holstein-Friesian
Unknown breed, number and age						+0.31	MASON *et al.* (1964)

In the experiment a non-significant negative correlation was generally found between the degree of inbreeding and the various body measurements, and this was closer than that found by the authors cited. It is not thought likely, however, that this difference was due to the different breed used in the present experiment.

The varying extent of depression is clearly shown, for the live weight too, by Figs 1—3. For the body measurements and live weights there is a general tendency for the average values of groups with an inbreeding coefficient of 0.312 (F) to exceed those of the control groups in most cases. After this value, the depression increases as the inbreeding coefficient rises. This tendency may be due to various circumstances. First of all, the extent of inbreeding and the depression caused by it are presumably not linear. The same conclusion was reached for a Hungarian Spotted cattle stock by VERESS—TÖRÖK (1969).

On the other hand, Wright's inbreeding coefficient may not give an exact indication of the actual homozygous state, as suggested by DOHY (1979) in his proposal for improving the method of calculating the inbreeding coefficient.

The correlation of the inbreeding coefficient (F) with the live weight was also determined for all the three ages studied. As seen in Table 3, in agreement with a number of foreign authors, no significant correlation was found between the two variables. Table 4 contains the live weights measured in the two sex groups at birth and at the ages of 6 and 12 months, according to the closeness of inbreeding. As was expected, the table reveals a significant difference ($P < 5\%$) between male and female animals at the same age (with a single exception). On the other hand, no correlation between sex (A) and changes in the live weight as a function of the degree of inbreeding (B) could be demonstrated.

The relevant literature contains very conflicting data on the extent of depression occurring as a consequence of inbreeding. HARWING (1964) carried out systematic inbreeding for 18 years with Hereford cattle and found that inbreeding caused a much smaller extent of depression than reported in most literary sources. At the age of 1 year the inbred calves were underdeveloped, though not significantly, compared to the control. By the age of two or two and a half this retardation gradually disappeared.

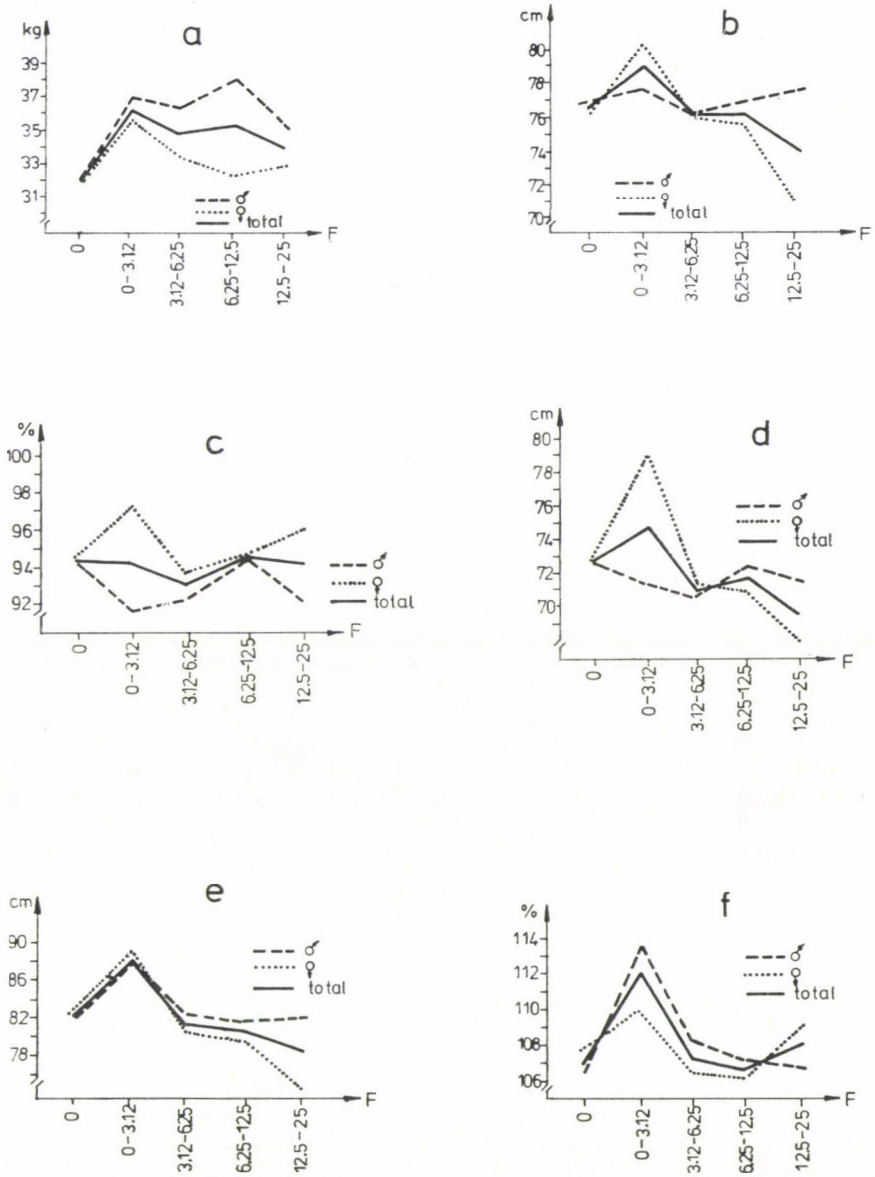

Fig. 1. Trends of birth weight and body measurements as a function of inbreeding (*a* = birth weight, kg; *b* = height of withers at birth, cm; *c* = length of trunk at birth, %; *d* = length of trunk at birth, cm; *e* = girth at birth cm; *f* = girth at birth, %)

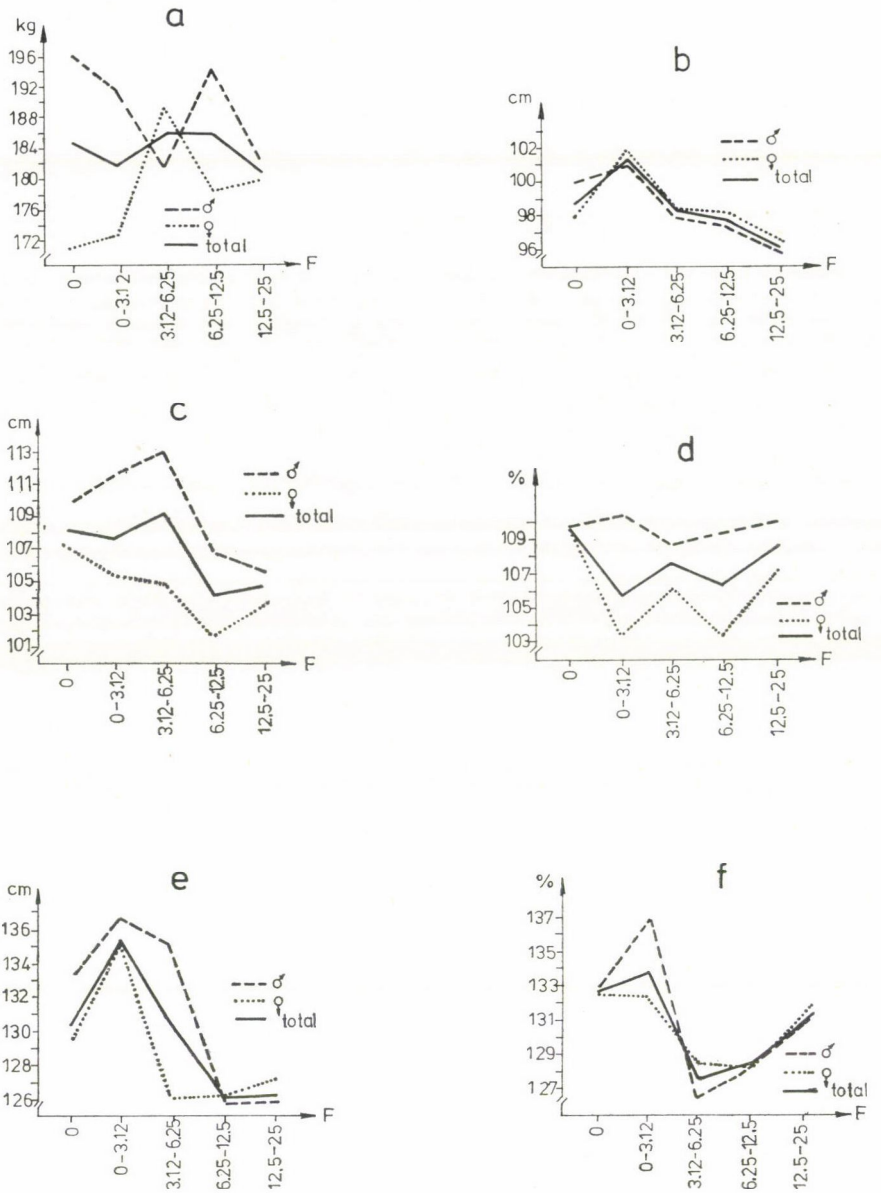

Fig. 2. Trends of live weight and body measurements at the age of 6 months as a function of inbreeding (*a* = live weight at 6 months of age, kg; *b* = height of withers at 6 months of age, cm; *c* = length of trunk at 6 months of age, cm; *d* = length of trunk at 6 months of age, %; *e* = girth at 6 months of age, cm; *f* = girth at 6 months of age, %)

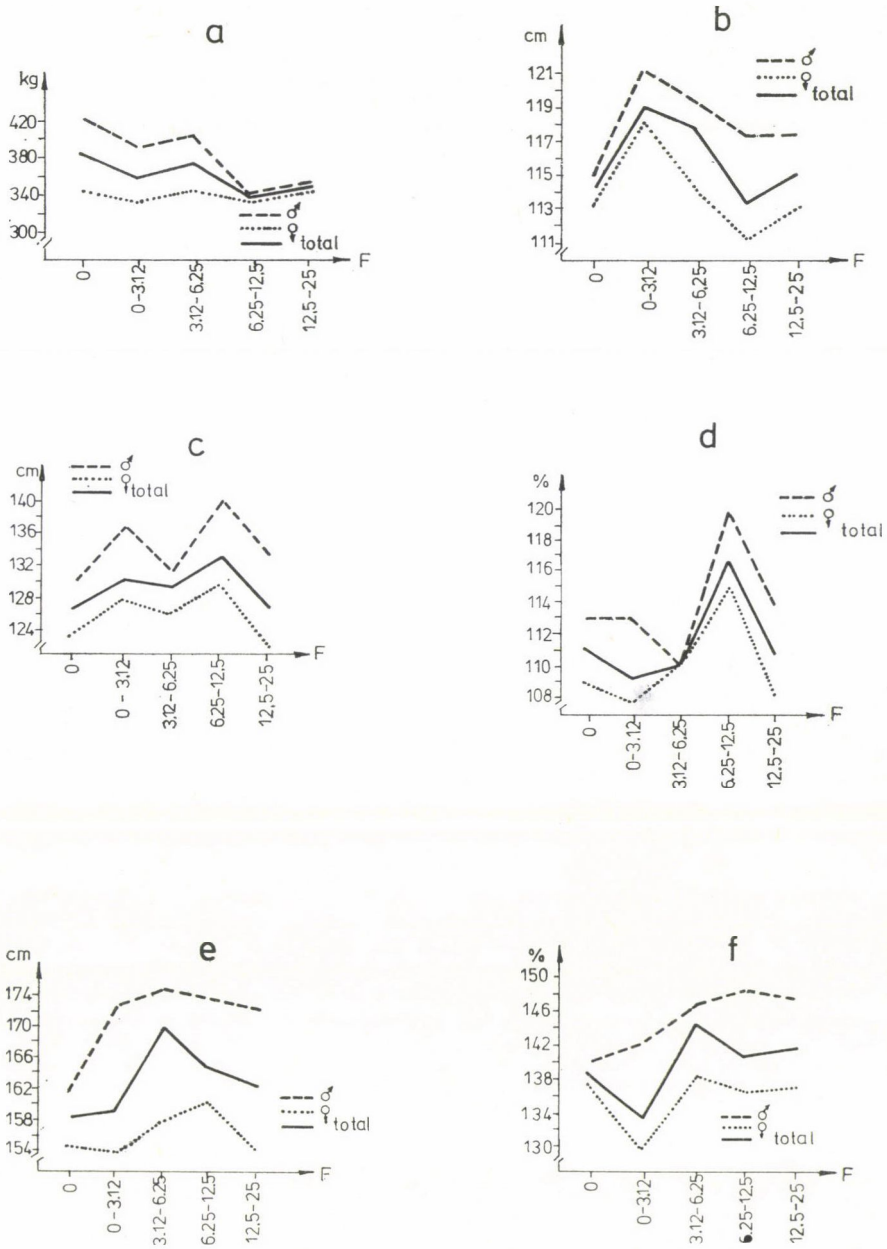

Fig. 3. Live weight and body measurements at the age of 12 months as a function of inbreeding (*a* = live weight at 12 months of age, kg; *b* = height of withers at 12 months of age, cm; *c* = length of trunk at 12 months of age, cm; *d* = length of trunk at 12 months of age, %; *e* = girth at 12 months of age, cm; *f* = girth at 12 months of age, %)

Table 3

Correlation between degree of inbreeding and body weight

	n	Average degree of inbreeding (F%)	r	b	Authors and breed
At birth	171	7.8	—0.12	—0.09	Authors' own data Hungarian Spotted cattle
6 months	163	6.9	—0.18	—0.19	
12 months	144	7.1	—0.20	—1.20	
6 months	940	10.9		—0.81	YOUNG *et al.* (1969) Holstein-Friesian
12 months	908	10.8		—1.88	
6 months	554	12.5		—0.99	SUTHERLAND—LUSH (1962) Holstein-Friesian

Correlation between live weight at 1 month of age (x) and live weigths at the ages of 3, 6 and 9 months (n = 13)

	n	Inbred animals	Non-inbred animals	Authors and breed
3 months	13	0.79	0.88	LIEBENBERG—BECKERT (1968) German Black Spotted
6 months	13	0.67	0.72	
9 months	13	0.68	0.86	

MARTYUGIN (1961) reports on experience gained with Halmogor cattle on the farm attached to the Timiryazov Agricultural College. He evaluated the data for 123 inbred ($F_x = 3.13-25.0\%$) calves. Their live weight was 38 kg at birth (39.7 kg in the control), 178 kg at 6 months (172 kg in the control), 304 kg at 12 months (291 kg in the control), 413 kg at 18 months (422 kg in the control) and 565 kg (compared to 541 kg in the control) after the first calving. After the second calving the average live weight was 608 kg for the inbreds and 585 kg for the control cows, and following the third calving the corresponding figures were 622 and 620 kg, respectively. The same tendency was observed by the author in the case of bull calves, and no substantial difference in body measurements was found between the two groups of animals either.

As opposed to the above authors, others report on depression occurring as a result of inbreeding.

HILLERS—FREEMAN (1964), for example, demonstrated a 0.14 kg reduction in birth weight for each 0—31% of inbreeding. Practically the same was established by MIG-PI (1963) who observed a reduction in the body measurements too. The regression of birth weight per inbreeding percentage was found to be still higher (0.9 kg) by SUTHERLAND—LUSH (1962). According to these authors cattle with 12% of inbreeding were 1.2 cm less in height and 0.8 cm less in girth at the age of 1 year. They add, however, that these differences in comparison to the control disappear after the age of 3. Although the present investigations were terminated before the animals reached this age, the phenomenon is considered probable on the basis of several characters corresponding to those described in the relevant literature.

In Guernsey and Holstein-Fresian cattle WOODWARD—GRAVES (1933) found lower live weights at birth and slower development as a consequence of intensive inbreeding. However, attention should be given to the statement made by these and other authors that the extent of reduction depends on the genetic constitution of the basic population.

According to JOHANSSON (1955), SCHÖNMUTH (1966) and IVANOVA (1964) the extent of inbreeding depression is a function of the genetic composition and quality of the initial population. In this context reference should again be made to the fact that the cows included in the present experiment presumably had an excellent constitution, since they lived to an old age (founders of families) and displayed high productivity. In addition, they calved regularly every year. On the basis of these properties a relatively moderate inbreeding depression was expected. The difficulties encountered in comparing the results for different experimental animal groups, in spite of the fact that they were characterized by a similar degree of inbreeding, are probably due to differences in methodology and in the genetic constitution of the experimental stocks. In some cases the data are not only impossible to compare, but are also contradictory.

From the above the conclusion was drawn that the differences between the results of the present experiment and some of the data in the relevant literature can be traced back to the different methodology applied, rather than to the breeds included in the experiments. With regard to its constitution the stock examined could be practically regarded as a selected stock (see the methodology of the experiment), while this was not characteristic of all the foreign stocks referred to.

All in all, from the literature cited and the results of the present investigations it can be established that

- depression must generally be expected as a consequence of inbreeding,
- the extent of depression appears to depend to a great extent on the constitution of the initial population,
- with advancing age the depression in inbred animals becomes more moderate, and, according to certain observations, disappears by the time the animals reach old age.

II. Effect of inbreeding on reproduction

In the present experiment the time interval between two calvings was primarily used to characterize the effect of inbreeding on reproduction. Although in the control the time between two calvings was some 13 days shorter ($\bar{x} = 409.7$ and 397.1 days, respectively), the difference was not significant.

The correlation between the degree of inbreeding and the time from one calving to the next ($r = -0.04$) was also calculated. The regression correlation is expressed by the following equation:

$$y = 416.7 - 0.93x$$

(the average for inbred animals $\bar{x} = 409.7$, $CV = 23.00x = -0.04$, significant at $P > 10\%$).

In a similar manner to the analysis of the time between two calvings, the correlation between the degree of inbreeding and the fertility index was calculated. The statistically non-significant correlation is characterized by the equation $y = 2.60 - 0.017x$ (the average for inbred animals $\bar{x} = 2.47$, $CV = 31.17$, $r = -0.19$, significant at $F = 0.97 < 10\%$).

On the basis of the data no relationship could be established between the two characters in the stock examined. In agreement with the opinion of FALCONER (1963) the lack of correlation is explained by the fact that inbreeding has a double effect on reproduction and on the factors influenced by maternal effects: it is due partly to the inbred nature of the

Table 4

Effect of inbreeding on birth weight and live weights

Age	Degree of inbreeding: F%												p% A/B
	control 0		0–3.12		3.13–6.25		6.26–12.50		12.51–25.00		Total		
	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	
At birth	28	32.11	19	37.11	19	36.55	25	38.27	19	35.56	110	35.74	5
	36	31.88	23	35.70	19	33.67	23	32.54	24	33.21	125	33.23	
Total	64	31.98	42	36.34	38	35.11	48	35.52	43	34.25	235	34.40	
6	30	196.75	19	191.67	19	181.67	20	194.00	18	181.88	106	190.09	—
months	27	171.18	23	173.08	19	189.44	23	178.46	22	179.58	114	177.69	
Total	57	184.64	42	181.49	38	185.55	43	185.69	40	180.61	220	183.67	5
12	21	420.45	17	392.86	18	403.13	16	346.67	16	355.00	88	386.26	5
months	21	346.82	23	334.23	19	346.11	17	332.14	18	344.38	98	340.73	
Total	42	383.64	40	359.15	36	373.85	33	339.18	34	349.38	186	362.27	0.1

Table 5

Amount and butterfat content of milk produced in the first and second lactation periods

Experimental group

Families	Lactation	n	Milk, kg	Butterfat	
				kg	%
Princ	I	10	3.069	124.83	4.07
	II	6	4.688	161.32	3.44
Galamb	I	4	3.145	133.20	4.24
	II	3	3.910	158.30	4.05
Csöngős	I	9	2.956	108.75	3.67
	II	7	4.236	165.00	3.91
Címer	I	8	3.664	148.85	4.06
	II	4	4.025	160.57	3.99
Piros	I	3	3.773	148.15	3.93
	II	2	4.317	176.59	4.09
Gerle	I	6	3.104	127.13	4.09
	II	4	3.810	170.40	4.47
Tulipán	I	16	3.467	135.58	3.92
	II	13	3.772	153.30	4.11
Total	I	55	3.312	132.40	3.99
	II	39	4.108	163.60	4.00

animals examined, and partly to that of the mothers. Thus, the correlation between the factors studied and the inbreeding coefficient cannot be determined in a simple way.

Owing to these difficulties it is not easy to draw rational conclusions on the exact form of inbreeding depression observed in the experiments. Further investigations are needed to clarify the matter.

Similar experience was gained by YOUNG *et al.* (1969) who, in an experiment in Wisconsin, compared non-inbred (normal) and inbred parents and their mating combinations in the following way:

1. mothers inbred to various degrees × normal father [non-inbred (normal) progeny]
2. normal mothers × bulls related to them (inbred progeny)
3. inbred mothers × inbred fathers related to them (inbred progeny).

In the course of the different types of combinations it was found that there was a tendency for depression in conception, intrauterine mortality, and in reproduction biological characteristics in general, to increase in the above order of combinations, but it was not statistically significant, presumably because an interaction can be observed between the genotype and the inbreeding depression within each combination. Other authors, e.g. NOWICKI (1963), found depression even in the case of a slight degree of inbreeding when expressing the fertility by the calving interval.

Table 6

Amount and butterfat content of milk produced in the first and second lactation periods

Control group

Families	Lactation	n	Milk, kg	Butterfat	
				kg	%
Princ	I	50	3.225	153.64	4.76
	II	49	3.991	159.95	4.02
Galamb	I	8	3.557	142.36	3.99
	II	8	4.062	163.24	4.02
Csöngős	I	16	3.579	140.76	3.90
	II	15	4.202	169.79	4.02
Címer	I	15	3.321	129.33	3.90
	II	15	3.825	146.26	3.82
Piros	I	9	3.321	130.64	3.93
	II	8	3.887	153.64	3.97
Gerle	I	12	3.672	138.95	3.81
	II	9	4.305	167.79	3.91
Tulipán	I	28	3.492	134.52	3.86
	II	28	4.335	161.64	3.72
Total	I	138	3.452	132.60	3.88
	II	132	4.087	160.22	3.95

PIRLEA—ILEA (1970) are also of the opinion that as a result of inbreeding the fertility index becomes less favourable.

In an experiment carried out for 10 years with cattle DAVENPORT—STONAKER (1965) demonstrated that inbreeding had a reducing effect on the number of progeny.

III. Effect of inbreeding on milk production and butterfat content of milk

The milk and butterfat production of the experimental and control cows in the 1st and 2nd lactation periods are shown in Tables 5 and 6.

An analysis of the data in these tables reveals that there is hardly any difference in average milk production between the experimental and control animals. Milk production in the two lactation periods is practically the same; the difference is not significant.

As for the butterfat percentage, the inbred animals are superior to the control in both lactation periods, as is also explained by the known negative correlation between the volume and butterfat content of the milk. The production of the experimental cow families as a function of inbreeding was subsequently evaluated by variance analysis with two variables. Families inbred to various degrees are represented as variable "B". The results of variance analyses on milk production, butterfat content and total amount of butterfat are contained in Tables 7 and 8. According to the data in these tables and in Tables 5 and 6, inbreeding did not cause a significant depression in milk production, although the average milk production of the experimental cows was 140 kg less in the first lactation period and 19 kg more in the second lactation period compared to the control.

It is noteworthy that the butterfat content in the milk of the experimental cows was $\bar{x} = 0.18\%$ more in the first lactation period; this difference is significant at $P < 0.1\%$. A similar tendency was observed in the second lactation period, with the difference that an interaction between variables A and B could also be pointed out, though only at $P < 5\%$ (Table 8). This correlation is even more pronounced for the amount of butterfat (kg fat), where the $A \times B$ interaction in the second lactation period is significant at $P < 0.1\%$ (Table 8).

Table 7

Variance in milk production

Variance	I				II			
	Lactation							
Factor	SQ	FG	MQ	F	SQ	FG	MQ	F
Total	144,504,883.51	192			133,519,701.79	170		
Between families (A)	2,822,368.99	6	470,394.83	0.61	1,629,549.93	6	271,591.66	0.34
Between relatives and non-relatives (B)	344,477.28	1	344,477.28	0.45	50,546.17	1	50,546.17	0.06
A×B inter-action	4,697,204.58	6	782,867.43	1.02	7,046,646.91	6	1,174,441.15	1.48
Error	136,640,832.66	179	763,366.61		124,792,958.78	157	794,859.61	

Table 8

Variance in butterfat production

	Variance	I				II			
		Lactation							
	Factor	SQ	FG	MQ	F	SQ	FG	MQ	F
Fat, %	total	18.64	192			14.89	170		
	between families (A)	0.28	6	0.0469	0.49	0.72	6	0.12	1.52
	between relatives and non-relatives (B)	1.25	1	1.2500***	13.11	0.60	1	0.60**	7.59
	A×B interaction	0.05	6	0.0083	0.082	1.09	6	0.18*	2.28
	error	17.06	179	0.0950		12.48	157	0.078	
Fat, kg	total	161,853.55	192			331,316.18	170		
	between families (A)	9,522.04	6	1,587.01	2.08	4,743.08	6	790.51	0.67
	between relatives and non-relatives (B)	5,007.30	1	5,007.30*	6.58	7.22	1	7.22	0.0061
	A×B interaction	11,217.55	6	1,869.59	2.46	141,603.80	6	23,600.63***	20.03
	error	136,106.66	179	760.37		184,962.08	157	1,178.10	

* P = 5%, ** P = 1%, *** P = 0.1%

This tendency confirms statements found in the literature in connection with other characters referred to earlier, namely, that the individual animals and genotypes give different responses to inbreeding, as is manifest in the variation in the amount of milk produced.

SOLOVYEV (1966) means much the same when he says that the milk of inbred animals originating from parents of firm constitution had a higher butterfat content than that of milk from their non-inbred paternal half-bloods.

In the literature referred to here no calculations were found which would prove an interaction between inbreeding depression and genotype, but it can be seen that opinions on the extent of depression in milk production are highly divergent. The significant correlation statistically demonstrated in the present paper should prove the hypothesis formulated in several papers, to the effect that different genotypes (individuals, blood lines) give highly varied responses to inbreeding. In some animals even a low degree of inbreeding causes depression, while with others inbreeding results in increased production. Between the two extremes innumerable transitional cases occur. To prove this various authors are cited here.

VERESS—TÖRÖK (1969) carried out investigations on a Hungarian Spotted cattle stock and found great variation in the milk production of inbred cows originating from breeder bulls of the same blood line. In the progeny of some bulls the depression could be well demonstrated, while in that of other bulls it was not visible; moreover, in some cases the average milk production of inbred cows exceeded that of non-inbred cows. VON KROSIGK—LUSH (1958) observed a linear reduction in milk production as a function of inbreeding. With a 1% increase in the F coefficient the lactation milk production decreased by about 26 kg. The butterfat content, on the other hand, increased (by 0.003% per 1% F). The authors explain this phenomenon by a negative correlation between butterfat content and milk volume.

WESSELY (1967) compared the first two lactations of inbred cows to the corresponding lactation production of the control and found that with a 1% increase in the degree of inbreeding the life production of milk and butterfat decreased by about 0.5%. ALLAIRE—HENDERSON (1965) observed a depression of 15.2 kg in milk production and 4.05 kg in butterfat content in the case of a 1% increase in the degree of inbreeding.

According to ARZUMANYAN (1963), under favourable conditions inbred cows with higher productivity are superior in milk production to non-inbred ones.

BYCHKOV *et al.* (1961) found the milk production of moderately inbred cows to exceed the milk production of unrelated control cows in every case, while cows originating from closely related parents produced somewhat less milk. Nearly identical results were obtained by PIRLEA—ILEA (1970) who found an increase in milk production from F = 3.12—6.25% of inbreeding and a 38.05 kg decrease with each 1% above that value.

NOWICKI (1963) reports on a significant (42.97 kg) increase in milk production and a 1.65 kg increase in butterfat content with every 1% rise in the inbreeding coefficient.

According to VLASOV (1970) inbreeding does not decrease the milk production, butterfat percentage or live weight of cows. In agreement with the present findings, he found that the variability in the characteristics did not lessen and homogeneity did not increase as a consequence of inbreeding.

Again, the literary data confirm the observation that inbreeding generally results in a slight increase in the milk components (butterfat %).

Table 9

Correlation between degree of inbreeding and milk production

	n	Average degree of inbreeding (F%)	Milk, kg		Butterfat, kg		Authors and breed
			r	b	r	b	
Lact. I	55	7.86	—0.03	— 3.07	0.19	0.73	Authors' own data
Lact. II	39	6.50	+0.12	+11.32	0.22	0.83	Hungarian Spotted
Lact. I	763	9.9		—24.0		—0.82	YOUNG *et al.* (1969)
Lact. II	784	2.8		—19.5		—0.54	Holstein-Friesian
Lact. III	264	2.5		—11.8		—0.23	
Butterfat, %			—0.36 Jersey		—0.20 Holstein-Friesian		TYLER *et al.*, TOUCHBERRY (1949, 1949)
Guernsey					—0.32		Farthing *et al.* cit. YOUNG *et al.* (1969)
Holstein-Friesian					+0.22		

Table 10

Correlation and regression between degree of inbreeding ($F\%$) and milk production parameters

		n	$\bar{y}$	$\pm s$	v%	r	F	y' = a + bx
Lact. I	milk, kg	55	3261	753.90	23.12	—0.03	0.02	y' = 3285 — 3.07x
	butterfat, kg	55	129.6	26.93	20.79	0.19	1.16	y' = 123.8 + 0.73x
	butterfat, %	55	4.06	0.38	0.49	0.29	2.79	y' = 3.94 + 0.015x
Lact. II	milk, kg	39	4259	715.46	16.80	0.12	0.25	y' = 4165.9 + 11.32x
	butterfat, kg	39	173.9	27.47	15.80	0.22	0.96	y' = 167.01 + 0.83x
	butterfat, %	39	4.1	0.29	7.11	0.23	0.97	y' = 4.03 + 0.0089x
Ratio of lact. I to lact. II		339	73.06	16.89	23.12	0.30	1.84	y' = 67.32 + 0.696x

MARTYUGIN (1961) came to the following conclusion when evaluating the butterfat production of cows. The butterfat production of inbred cows exceeded the production of the control by 6.5, 9.0 and 7.0% in the first, second and third lactation periods, respectively. He compared the milk production of the cows to the corresponding milk production of the mothers.

According to VERESS—TÖRÖK (1969) the butterfat content of the milk is less affected by inbreeding than the amount of milk.

On processing the data the correlation between the degree of inbreeding (F) and the volume of production was calculated. The correlation coefficients and their regression for the individual production characteristics and for the ratio of lactation periods I and II are contained in Table 9, together with data from a number of foreign authors. It is noteworthy that with advancing age and with an increase in the number of lactations the correlation between inbreeding and production becomes less close. According to the calculations the degree of inbreeding did not substantially influence the milk and butterfat production of the cows. This statement is confirmed by Table 10, where the regression equations are presented. When evaluating the results two factors should be emphysized once again. First, animals of different genetic composition give different responses to inbreeding. Secondly, in the present case the experiment was planned in advance, while a considerable proportion of the literary data are the results for animals originating from "spontaneous" inbreeding, looked up in registers to serve as the basis of evaluation. In the present case the firm constitution of the cow families included in the experiment was a principal requirement. The cow families selected excelled in length of life and productivity, which are basic indicators of a good constitution. These factors would appear to account in the present case, too, for the loose correlation between inbreeding and milk and butterfat production.

IV. Fattening characters of beef bulls originating from inbreeding

Although the young animals, whether inbred or not, behaved in the same way during fattening as those raised for breeding, a considerable difference may nevertheless be caused by the fact that slaughter animals are fed practically ad libitum and do not live so long, so

Table 11

Comparative values of slaughter-house quality control

Groups	n	Live weight before slaughter, kg	Fresh half-carcass weight, kg	Slaughter percentage, %	Fistola cut		Abdominal fat, kg
					kg	%	
Control	15	561	341.4	60.8	152.4	44.6	24.06
Experimental	20	546	332.3	60.8	140.9	42.4	21.02

F = 3.0—12.5%

Table 12

Correlation (r) between the degree of inbreeding (F) and some characteristics determining the slaughter value; regression of the characteristics

Designation	Y	$\pm s_y$	$v\%_y$	r	F*	$5/ = a + by$
Fresh half-carcass, kg	332.30	22.81	6.86	0.08	0.05	y' = 329.88 + 0.41x
Abdominal fat, kg	21.02	3.40	16.18	—0.002	0.00	y' = 21.03 — 0.0015x
Abdominal fat, %	6.34	0.97	15.45	—0.044	0.02	y' = 6.37 — 0.0099x
Abdominal fat, kg	140.90	7.84	5.56	0.36	1.32	y' = 137.27 + 0.644x
Abdominal fat, kg	42.39	3.08	7.27	0.19	0.32	y' = 41.65 + 0.131x
Weight of 4 legs, kg	8.67	0.74	8.57	0.29	0.81	y' = 8.39 + 0.049x

* F value of variance analysis.

there is no chance of the differences between them and the non-inbred animals later disappearing.

In the case of young beef bulls observations similar to those described for the young breeding heifers were made. The live weight and body measurements led to the same conclusions for slaughter animals as for breeding animals; therefore, these data are not presented, and only the slaughtering characteristics are discussed here.

Twenty inbred (F = 3.0—12.5%) beef bulls were compared for slaughter value with 15 beef bulls from the same farm, unrelated with the experimental animals (control). The major parameters are summed up in Table 11.

The slaughtering percentage for beef cattle slaughtered with nearly identical live weight at about the same age was completely uniform (Table 11). In general the slaughtering characteristics were not adversely influenced by inbreeding, as seems to be proved by the data in Table 12, too. No correlation was found between the degree of inbreeding and the parameters shown in the table. The relation was relatively the closest (r = 0.36) for the absolute weight of the pistola cut. However, if it is related to the weight of half-carcasses measured when still warm even this loose correlation will further decrease (r = 0.19).

The data in Tables 11 and 12, as well as the results of investigations made by KIRST—SCHÖNMUTH (1969) with young bulls of the German Black Spotted breed (with an inbreeding coefficient of F = 0.25), show that in the case of fattening with farm fodder there is no difference in body measurements and quantitative characters between the carcasses of inbred

and control bulls. This confirms the statement made when evaluating the growth and development of young breeding animals, namely, that with increasing degrees of inbreeding the extent of depression shows wide variations. Deterioration is in most cases very slight and statistically not proved. The small number of experimental animals does not, however, allow far-reaching conclusions to be drawn from the slaughtering results. It is, therefore, necessary to continue the investigations with a view to settling this question.

V. Examination of lethal and sublethal genes

In a central progeny testing station 4 breeder bulls were mated with their female progenies. The percentage of conception, the length of the gestation period, and the birth weight, body measurements, constitution and vitality of the new-born calves were examined.

It was found that the conception, gestation period, birth weight, and the body measurements taken at the age of one day did not essentially differ from the corresponding values of calves originating from unrelated parents. On the other hand, the progeny of the same bull showed a substantial variation, particularly in vitality.

A large proportion of the progeny of the bull 1438 Apacs displayed conspicuous degeneration. It is noteworthy that this kind of injury can be detected, though to a lesser extent, in the progeny of this bull with unrelated mothers. This observation agrees with the conclusions of Le Roy (1964), who found that if a recessive hereditary deficiency appears in 1% of the progeny of a non-inbred population, then 1.5—1.9% or 3.3% of undesirable genes must be expected in the case of 5—10% or 25% inbreeding, respectively.

Of the progeny derived from mating 1438 Apacs with related cows (25% inbred calves) 33% died or were slaughtered, 25% survived but showed a high degree of degeneration, while 42% were seemingly healthy (Table 13).

Animals which survived but showed deficiencies can be characterized by the following:

1. Serious enfeeblement after birth, absence of sucking and swallowing reflexes.
2. Remarkably loose joints. The most conspicuous deficiencies of constitution: loose shoulder-blades, sunk withers, curved back, soft pastern.
3. Covered joints.
4. In one case a hare-lipped calf was born (the lower jaw was 3—4 cm shorter than normal). 1438 Apacs may thus be a latent carrier of these deficiencies.

Table 13

Characterization of progeny of the bull 1438 Apacs from related and unrelated cows, and of contemporary progeny of other bulls

	Mating of 25% relatives		Control			
			Progeny of Apacs		Contemporaries	
	number of animals	%	number of animals	%	number of animals	%
Total births	12	100	231	100.0	363	100.0
Perished or emergency slaughtered	4	33	35	15.1	44	12.1
Alive but injured	3	25	—	—	—	—
Apparently healthy	5	42	196	84.9	319	87.9

This case calls attention to several circumstances:

a) Bulls with lethal or sublethal genes occur in the Hungarian Spotted breed.

b) Close inbreeding (in this case father × daughter) makes it clear even in the case of a low number of individuals whether undesirable genes occur in the genetic material of the breeder bull.

c) The damaging effect of undesirable genes appears to be demonstrable in tendency even if inbreeding is not employed.

MORLEY (1954) assumes that most cattle carry the gene of at least one lethal factor in a latent heterozygous state. Such latent characteristics can be discovered by close inbreeding. Darlington, Mather, Falconer, Hammond, Rendel and Robertson (MÁRKUS 1962) as well as VERESS—TÖRÖK (1969), think it necessary to detect bulls affected with hereditary abnormalities.

According to JOHANSSON (1955), MÁRKUS (1962), MASON (1964), LERNER—DONALD (1966) and Rendel—Gravert cit.: RIECK 1969 the fear of spreading undesirable genes by artifial insemination is irrational. Nevertheless, RIECK (1969) notes that these optimistic

Table 14

Milk and butterfat produced in the different lactation periods by the progeny of the F = 25% inbred breeder bull 10/7 Lottó

Lactation	n	Experimental		Cow groups		Control		
		$\bar{x}$	±s	v%	n	$\bar{x}$	±s	v%
I	61	2837	662.2	23.32	50	2935	805.6	27.45
II	56	4034	623.3	15.45	42	4070	877.9	21.57
III	52	4448	731.0	16.43	33	4445	833.1	18.74
IV	42	4802	958.8	19.97	27	4465	790.0	17.69
V	36	4747	949.0	19.91	19	4693	1305.0	28.06
VI	35	4834	855.2	17.69	11	4656	885.6	19.02
VII	21	5205	1105.3	22.39	5	4849	1131.1	23.33
VIII	10	5084	583.0	11.48	1	4183	—	—
IX	2	5578	810.0	14.53	—	—	—	—
				Butterfat, kg				
I	61	113.5	25.66	22.51	50	117.2	30.88	26.34
II	56	158.1	22.46	14.21	42	163.2	30.06	18.42
III	52	172.1	29.05	16.89	3	177.3	29.77	16.79
IV	42	188.0	34.52	18.37	27	178.0	27.91	15.69
V	36	184.2	36.59	18.86	19	188.1	42.19	22.43
VI	35	188.9	33.43	17.69	11	185.5	27.43	84.78
VII	21	203.0	44.78	22.06	5	192.7	39.24	20.37
VIII	10	195.8	19.06	9.74	1	170.7	—	—
IX	2	209.1	23.83	11.39	—	—	—	—

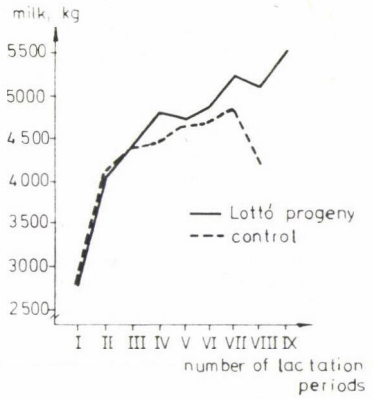

Fig. 4. Milk production by the first generation progeny of an inbred bull compared to control animals of the same age

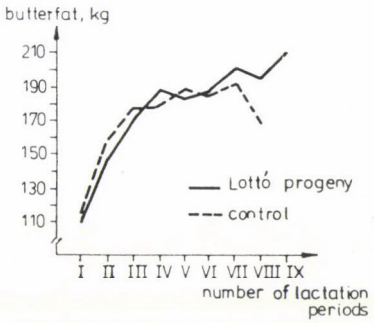

Fig. 5. Butterfat production by the first generation progeny of an inbred bull compared to control animals of the same age

views and uncertain opinions can be traced back in part to the fairly small amount of exact experimental evidence available concerning domesticated animals.

Horn—Dohy (1970) do not consider it necessary to use test combinations in the case of artificial insemination in order to detect possible lethal factors. Experience gained by keeping a large number of progeny under observation is — in their opinion — sufficient.

In some countries (e.g. in the German Democratic Republic) the practice suggested earlier of testing the hereditary abnormality of breeder bulls by mating them with their first generation female progeny has recently been employed.

The proportion of bulls with lethal or sublethal genes in a given population (breed) does not seem to have been the subject of investigation anywhere.

On the basis of the present experiments the frequency of occurrence cannot be related to the breed, owing to the small number of observations. However, even these results make it questionable whether close inbreeding aimed at detecting lethal and sublethal genes is profitable, considering the possible depression in the production of the female progeny.

Johansson (Kolataj 1970) admits the justification for special tests to demonstrate lethal genes, especially in male domestic animals, but uses numerous examples to prove that

lethal and sublethal genes do not represent any danger in a given population if the frequency of recessive genes is low. For example, if the proportion is 5% or lower such genes may be widely distributed in a latent heterozygous state. In the case of artificial insemination, when a large number of cows are fertilised with the sperm of a single bull, special tests are not needed to pick out the carrier of the abnormality.

Accordingly, it is debatable whether it is wise to insist on testing breeder bulls for lethal and sublethal genes by means of close inbreeding, which is usually unfeasible anyway. It is, however, worth considering how to collect, process and evaluate the widest possible range of data on the vitality of new-born calves in the course of progeny testing.

Table 15

Number of animals per lactation

(Percentage distribution, lactation I = 100)

Groups	I	II	III	IV	V	VI	VII	VIII	IX
Experimental	108	92	85	69	59	57	34	16	3
Control	100	84	66	54	38	22	10	2	—

Table 16

Age of the progeny of the inbred bull 2617 Tulipán and of the control bulls when calving (months)

Standard deviation

Designation	n	$\bar{x}$	$\pm s$	CV
		for the group		
2617 Tulipán	14	27.57	0.85*	3.09
2682 Juta	11	27.64	1.12	4.05
2685 Villám	3	28.00	1.00	3.57
2683 Rumos	12	27.42	1.00	3.63
2684 Prímás	18	27.50	1.10	3.99
2687 Zerge	12	27.83	1.11	4.00
269 Fáraó	9	27.67	1.58*	5.72
	79	27.61	1.11	4.02

$F = 3.45 \quad P = 10\%$

Variance

Factors	SQ	FG	MQ	F
Total	90.84	78		
Between groups	1.78	6	0.39	0.24
Within groups	89.06	72	1.23	

VI. Effect of inbred bulls on the milk production of the progeny

During the experiment it was possible to trace and record the production of the progenies of two inbred bulls. In evaluating the milk and butterfat production of the experimental animals the production of cows of the same age and from the same cow-shed were used as a control.

a) The inbred bull 10/7 Lottó had been used on the farm for a long time, so it was possible to trace the production of its first generation female progeny over several years.

Data on the average milk and butterfat production of the experimental and control cows are contained in Table 14.

It is noteworthy that the milk production of the experimental cows exceeded that of the control only in the third lactation period, though from then on the former were always superior to the latter in production (Fig. 4). As regards butterfat production the tendency is not so unambiguous, as shown by Fig. 5. The same conclusion was arrived at by BYCHKOV *et al.* (1961), who described some characteristics in the inbred and non-inbred first generation female progeny of an inbred bull and in the contemporary control. The live weights of the cows were 577, 664 and 614 kg, and the total volumes of milk produced in 300 days of lactation were 6,452, 6,459 and 6,463 kg, respectively. These data show that the inbred progeny

Table 17

Live weight of progeny of the inbred bull 2617 Tulipán and of the control bulls after calving
(kg)

Standard deviation

Designation	n	$\bar{x}$	$\pm s$	CV
		for the group		
2617 Tulipán	14	526.79	54.55*	10.35
2682 Juta	11	523.64	41.30	7.89
2685 Villám	3	560.00	26.46*[1]	4.72
2683 Rumos	12	559.17	47.19	8.44
2684 Prímás	18	556.11	44.61	8.02
2687 Zerge	12	560.83	37.77	6.73
2693 Fáraó	9	526.67	51.23*[2]	9.72
	79	544.37	45.97	8.44

$x^1F = 4.25 \quad P = 2\%$
$x^2F = 2.09 \quad P > 10\%$

Variance

Factors	SQ	FG	MQ	F
Total	173,118.35	78		
Between groups	20,972.34	6	3,495.39	1.65
Within groups	152,146.01	72	2,113.14	

Table 18

Milk production of progeny from the inbred bull 2617 Tulipán and from control bulls
(kg)

Standard deviation

Designation	n	$\bar{x}$	$\pm s$	CV
		for the group		
2617 Tulipán	14	2330.64	848.59*	36.41
2682 Juta	11	2561.55	677.17	26.44
2685 Villám	3	2218.00	426.70*	19.24
2683 Rumos	12	2441.25	721.55	29.56
2684 Prímás	18	2774.00	669.89	24.15
2687 Zerge	10	2344.50	866.67	36.97
3693 Fáraó	9	2554.11	711.89	27.87

$F = 4.04 \quad P > 10\%$

Variance

Factors	SQ	FG	MQ	F
Total	40,819,016.88	76		
Between groups	2,337,749.30	6	389,624.88	0.71
Within group	38,481,267.58	70	549,752.39	

of an inbred bull is inferior in live weight and equal in average milk production over 300 days of lactation to both the paternal half-bloods and the unrelated control animals. A more exact evaluation of the observations is made impossible by the fact that the authors do not specify the degree of inbreeding either for the bull or for the inbred cows and their progenies. According to SOSTAK (1962) the volume of milk produced by the first generation female progeny of an inbred bull exceeded the milk production of the control by 6%.

HANSEN-LARSEN (1952) found the breeding value of inbred bulls to be more favourable than was judged from their exterior.

The extent of the absolute and relative deviation in the characteristics is also important. The data in Table 14 reveal that the individual variations in milk and butterfat production are substantially lower in the progeny of an inbred bull. This suggests homogeneity in the production of the progeny, although this could not be statistically proved. It should be noted, however, that ARZUMANYAN (1963) did not find uniform homogeneity even in the progeny of bulls with the same degree of inbreeding. There are great individual genetic differences in this respect, too.

Further, the vitality in the progeny of the experimental bull was studied, and, as a characteristic indicative of the constitution, the mortality percentage compared to the number of animals in the first lactation period.

The data are summed up in Table 15. It is noteworthy that while nearly half of the control animals did not live until the fifth lactation period, 57% of the experimental animals

were productive even in lactation period VI, while 34% of them survived until the seventh and 16% until the eight lactation period. This suggests that if animals of really high breeding value are used for inbreeding, the production of the progeny of a 25% inbred bull will reach a level corresponding to the hereditary productivity of the bull and show a more than average homogeneity. In the case of the bull examined the valuable gene may have been safely transmitted, whereby the production of the female progeny was better and its useful life longer. On the basis of this case and of this supposition, methods of close inbreeding, such as for example line crossing, may command interest in the future, too. The application of such methods for this purpose will only be possible in certain cases, however. The favourable experiences cannot be generalized and success depends to a large part on the breeder's intuition.

b) Within the framework of an official progeny test the first generation female progeny of 2617 Tulipán, a 10.93% inbred bull, was examined for the following aspects:

— age when breeding started,
— live weight on first calving,
— milk and
— butterfat production.

Age on first calving is shown in Table 16. The progeny of the bull examined were put to breeding at the same age as the control, but became pregnant within a shorter time, as

Table 19

Butterfat production for the progeny of the inbred bull 2617 Tulipán and for those of control bulls
(kg)

Standard deviation

Designation	n	$\bar{x}$	$\pm s$	CV
		for the group		
2617 Tulipán	14	90.23	30.17*	33.43
2682 Juta	11	94.46	26.27	27.81
2685 Villám	3	83.37	16.92*	20.29
2683 Rumos	12	94.33	24.64	26.12
2684 Prímás	18	101.49	21.87	21.55
2687 Zerge	12	76.12	30.46	40.02
3693 Fáraó	9	92.54	26.94	29.11
	79	91.87	26.39	28.72

$F = 3.18 \quad P > 10\%$

Variance

Factors	SQ	FG	MQ	F
Total	55,170.77	78		
Between groups	5,050.90	6	841.82	1.21
Within group	50,119.87	72	696.11	

indicated by the lowest variation in the calving time (CV = 3.09). In this case neither the heifers nor the breeder bull were inbred, only the male parent of the heifers (see above).

Table 17 shows the average live weight of heifers in first calf following calving; this live weight may be indicative of the growth vigour of the animals when young. In this respect the non-inbred female progeny of the inbred bull were inferior to those of control bulls raised at the progeny testing station. Moreover, they were no better than the control as regards homogeneity either (CV = 10.35).

The amounts of milk and butterfat produced by the progeny of the 10.93% inbred bull when in first calf were recorded for the first lactation period (Tables 18 and 19). The progeny of this bull were inferior to the control as regards both milk and butterfat production. The progeny of the inbred bull were fairly heterogeneous in other characters as well.

An attempt was made to analyse the variation in the experimental groups using a mathematical test. They were compared for variance with the control progeny group which showed the lowest variation. With this method the standard deviation proved significant in none of the cases (in Tables 16—21 the groups compared are marked with asterisks).

c) Propensity for fattening in the progeny of inbred bulls.

The progeny of two bulls inbred to different degrees were tested with respect to their propensity for fattening. Weight increase and the daily variation during the fattening period are shown in Tables 20 and 21 for the progeny of Tulipán (F = 10.93%), which was mentioned earlier and of Pajti (F = 6.25%). The progeny of Pajti displayed average qualities and those

Table 20

Average daily weight gain during fattening in progeny groups from a F = 10.93% inbred bull and from control bulls
(kg)

	n	$\bar{x}$	$\pm s$	v%
Tulipán	12	1,483.25	163.88*	11.05
Juta	13	1,649.23	103.04*	6.25
Prímás	13	1,526.00	177.08	11.60
Zerge	13	1,502.77	202.56	13.48
Fáraó	13	1,551.00	188.31	12.14
Rumos	13	1,534.23	165.15	10.77
Villám	12	1,718.83	142.46	8.29

F = 2.53 P > 10%

Variance

Factors	SQ	FG	MQ	F
Total	2,808,298.81	88		
Treatment	541,335.96	6	90,222.66**	3.26
Error	2,267,692.85	82	27,653.57	

** P = 1%

Table 21

Average daily weight gain from the beginning of fattening until the evaluation in progeny groups of a F = 6.25% inbred bull and of control bulls
(From 180 to 500 days of age)

Name of progeny groups	n	Weight gain, g		
		$\bar{x}$	±s	v%
Pajti	14	1350.94	110.62*	8.19
Apacs	14	1316.1	114.24	8.68
Pálma	12	1342.02	111.73	8.33
Morcos	12	1297.22	59.40*	4.58
Formás	14	1359.54	152.59	11.22
Erős	13	1356.08	80.02	5.90
Lámpás	14	1358.06	81.54	6.00
Sarlós	14	1364.29	133.61	9.79
Total	107	$\bar{x} = 1343.79$		

$F = 3.42 \quad P > 10\%$

Variance

Factors	SQ	FG	MQ	F
Total	1,254,550.63	106		
Treatment	51,697.92	7	7,379.70	0.61
Error	1,202,892.71	99	12,150.43	

of Tulipán lower than average qualities. From the point of view of the experiment an analysis of the variance in the characteristics is more important. In this respect the progeny of neither bull provides a sufficient basis for establishing definite rules. This applies not only to the weight increase but to all the properties examined, such as exterior, shape of meat, slaughtering value and meat qualities.

One explanation for this phenomenon is that in breeding practice the gene stocks of selected bulls are in close agreement, according to the Hardy-Weinberg rule, with the gene frequency of the population they will be mated with. However, the genotype of the inbred bull is restricted to the blood line it was inbred for. Consequently, the difference between the inbred bull and the population mated with him will be greater. This difference may account for the fact that the progeny — while more homogeneous in genotype — are not more unit form as regards phenotypic characters than animals derived from an average mating.

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ROLE OF TITANIUM IN THE LIFE OF PLANTS. IV. EFFECT OF TITANIUM ON THE GERMINATIVE ABILITY OF WHEAT, MAIZE AND SUNFLOWER SEEDS AND ON THE GROWTH OF SEEDLINGS

In previous publications an account has been given of the considerable increase in yield and the improvement in composition caused by foliar nutrition with titanium-chelate solutions in various plant species (PAIS *et al.* 1977a, 1979, FEHÉR *et al.* 1980). On the basis of seed dressing experiments carried out by other authors with microelements which are considered to be essential it was aimed to study the microelement effect of titanium. In experiments with rubidium and titanium compounds VLASYUK *et al.* (1967) found the two elements to increase the activity of certain enzymes in germinating grains of wheat and maize when the elements were applied at a relatively high (nearly 200 ppm) concentration.

To determine the optimum quantity in seed dressing experiments titanium was used at concentrations of 0.2, 0.02 and 0.002 g Ti-ions/kg seed (T_1, T_2 and T_3). Seeds were also treated with corresponding concentrations of "Kelatol"* solution (K_1, K_2, K_3), while the control was given ion-free water of the same volume. In the wheat and maize experiments the two kinds of treatment were carried out in six replications each. In each treatment 50 wheat and 30 maize grains were used. The germination test was carried out at 20—22 °C with the BP

* "Kelatol" means the ascorbic acid.

method in a light chamber furnished with an automatic humidifier. On the sixth day of germination the plant height was measured and the activity of the catalase and peroxidase enzymes in the leaves of the plants was determined.

In earlier experiments (PAIS *et al.* 1977b) it was found that in the leaves of plants sprayed with titanium chelate the amount of chlorophyll significantly increased, and experience showed that the plants developed more vigorously. Titanium, as a transition element of varying oxidation number, is presumably able to influence the oxidation-reduction processes and the activity of enzymes taking part in them. When studying the leaves of vine plants treated with titanium compounds DOBROLYUBSKY (1961) made the same observation. This is why it was decided to measure the activity of the catalase and peroxidase enzymes generally used as physiological parameters.

On the basis of phenological observations it was found that as a response to treatments with the two lower concentrations of titanium the germination of seeds started one or two days earlier, the root formation was more vigorous and the growth of the seedlings more uniform than in the control. The solution containing the highest concentration of titanium

Table 1

Lengths of seedlings in titanium-treated wheat samples

Variety	Treatment	Lengths of seedlings, cm						Average	$LSD_{5\%}$
		I	II	III	IV	V	VI		
Jubileinaya	T_1	11.25	9.84	9.02	11.41	10.24	11.00	10.46	
Jubileinaya	T_2	12.21	10.61	9.22	11.42	11.05	11.96	11.07	
Jubileinaya	T_3	12.61	11.62	11.36	12.86	11.86	12.77	12.18	0.748
Jubileinaya	K_1	11.04	9.53	7.90	11.21	9.93	10.83	10.07	
Jubileinaya	K_2	11.12	9.44	7.94	11.30	10.00	10.91	10.11	
Jubileinaya	K_3	12.03	10.25	9.09	11.49	10.14	11.22	10.70	
Jubileinaya	control	11.37	9.91	9.14	11.54	10.52	11.44	10.65	

Table 2

Lengths of seedlings in titanium-treated maize samples

Variety	Treatment	Lengths of seedlings, cm						Average	$LSD_{5\%}$
		I	II	III	IV	V	VI		
TC 3344/A	T_1	1.62	1.85	3.60	1.72	2.01	1.87	2.11	
TC 3344/A	T_2	4.45	4.64	4.41	4.52	4.73	4.45	4.53	
TC 3344/A	T_3	4.69	4.80	4.51	4.71	4.90	4.70	4.72	0.148
TC 3344/A	K_1	3.88	2.77	2.73	3.90	3.79	3.00	3.34	
TC 3344/A	K_2	2.50	3.93	3.74	3.68	3.84	3.87	3.59	
TC 3344/A	K_3	3.91	4.00	4.02	4.03	4.16	3.90	4.00	
TC 3344/A	control	4.02	4.13	3.98	4.12	4.45	3.90	4.10	

Table 3

Activity of catalase enzyme in titanium-treated wheat seedlings

Treatment	Decomposed H_2O_2, mg	Standard deviation	$LSD_{5\%}$
T_1	8.68	0.73	
T_2	15.95	2.05	
T_3	16.45	1.64	3.58
K_3	7.92	1.33	
Control	10.60	1.85	

The amount of decomposed H_2O_2 refers to 1 g plant material.
Number of replications: 3.
Number of measurements: 12.

Table 4

Activity of catalase enzyme in titanium-treated seedlings of maize

Treatment	Decomposed H_2O_2, mg	Standard deviation	$LSD_{5\%}$
T_1	2.78	0.58	
T_2	4.99	0.60	
T_3	4.43	1.03	1.40
K_3	2.34	0.12	
Control	2.77	0.43	

The amount of decomposed H_2O_2 refers to 1 g plant material.
Number of replications: 3.
Number of measurements: 12.

Table 5

Activity of peroxidase enzyme in titanium-treated wheat seedlings

Treatment	Specific activity of peroxidase, E/ml	Standard deviation	$LSD_{5\%}$
T_1	17,730	380	
T_2	14,740	380	
T_3	19,840	390	815.24
K_3	16,290	400	
Control	13,440	210	

Number of replications: 3.
Number of extinction measurements: 21.

(0.2 g-ion/kg seed) did not cause any change in wheat, but had an inhibitory effect on maize. This made itself felt in a 1—2 day delay in the beginning of germination, shorter, thinner roots and uneven development of the seedlings. The data in Table 2 also show that the T_1 treated plants were considerably shorter than those in the other treatments.

The lengths of the seedlings are seen in Table 1 and 2. The data of treatment T_3 show a significant deviation compared to the control, both for wheat and maize.

The activity of the catalase enzyme was determined by the SZALAI—FRENYÓ (1962) method, while the peroxidase activity was measured by the method of MIHÁLYI—VÁMOS-

Table 6

Activity of peroxidase enzyme in titanium-treated maize seedlings

Treatment	Specific activity of peroxidase, E/ml	Standard deviation	$LSD_{5\%}$
T_1	3,500	66	
T_2	7,820	121	
T_3	8,590	160	367.53
K_3	7,120	170	
Control	8,220	240	

Number of replications: 3.
Number of extinction measurements: 21.

Table 7

Germination test on titanium-treated sunflower seeds

	0.2 g Ti-ion/kg	0.02 g Ti-ion/kg	0.002 g Ti-ion/kg	Control
Germinated seed, n	200	200	200	200
Intact germs, n (25 °C, after 5 days)	169	179	187	185
Germination, %	84.5	89.5	93.5	92.5
Abnormal germ, %	9.5	7.0	4.5	3.5
Rotten germ, %	6.0	3.5	2.0	4.0
Root length, cm (25 °C, after 5 days)	11.28	10.66	10.44	9.76
s	0.61	0.39	0.82	0.48
$LSD_{5\%}$	0.56	0.44*	0.68*	
Stalk length, cm (25 °C, after 5 days)	5.19	6.66	6.14	5.72
s	0.52	0.50	0.76	0.52
$LSD_{5\%}$	0.53	0.52*	0.66	

* Significant difference.

Table 8

Forcing test on titanium-treated sunflower seeds

	0.2 g Ti-ion/kg	0.02 g Ti-ion/kg	0.002 g Ti-ion/kg	Control
Planted, n	40	40	40	40
Emerged, n (19 °C, after 13 days)	32	34	36	28
Emerged, %	80	85	90	70
Plant height, cm (19 °C, after 13 days)	6.68	5.48	7.13	4.65
s	2.05	2.31	2.11	2.45
$LSD_{5\%}$	1.18*	1.22	1.16*	
Plant height, cm (19 °C, after 15 days)	8.22	8.01	9.01	6.55
s	2.24	2.16	1.92	2.78
$LSD_{5\%}$	1.30*	1.27*	1.21*	
Plant height, cm (19 °C, after 19 days)	9.86	9.50	9.39	8.83
s	2.59	2.01	1.60	2.25
$LSD_{5\%}$	1.24	1.08	0.99	
Plant height, cm (19 °C, after 28 days)	17.2	16.2	18.0	17.9
s	2.87	2.18	2.69	3.73
$LSD_{5\%}$	1.73	1.58	1.64	

* Significant difference.

Vigyázó (1975). The results are contained in Tables 3, 4, 5 and 6. Each of the data in Tables 3 and 4 represents the average of four parallels with a standard deviation of 1—2%. The greatest increase in catalase and peroxidase activity was caused by the lowest (0.002 g-ion) concentration of titanium. This was significant compared to the control both in wheat and maize. Changes in the activities of oxidation-reduction enzymes may, in accordance with expectations, be indicative of the effect of titanium on the physiological processes of seedlings.

In carrying out seed dressing experiments with GK-70 elite seed of sunflower the same concentrations of titanium were applied as for wheat and maize, making use of the experiences gained with these plants. Data on the germination of the seeds, length of roots and growth of stalks are summed up in Table 7. Since the growth rate of the seedlings showed a noticeable variation, seeds treated with different concentrations of titanium were sown in boxes and germinated in the phytotron, where the seedlings were raised to a stage of 2—3 foliage leaves. The germination percentage and the growth of the stalk above the soil were established (Table 8).

The results show that the germination of sunflower seeds was less affected by the titanium treatment, although in the phytotron experiment a higher germination percentage was obtained. The root growth was promoted by all three concentrations of titanium but the growth of the stalk only by the two lower ones.

According to the results of the phytotron experieent the treated plants were significantly taller than the controls until the fifteenth day after sowing; later measurements no longer showed significant differences.

As a final conclusion on the experiments, it can be established that titanium applied at concentrations of 0.02 and 0.002 g-ion/kg seed accelerates the initial development of the seedlings of all three plants examined. The titanium chelate treatment could be successfully used in cases when for some reason or other sowing is delayed, or the seed germinates slowly.

*

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GERMINATION PHYSIOLOGY OF TOBACCO SEED

After maturing most seeds enter the post-maturing phase. During post-maturing, germination is generally inhibited. This phase may last for months or even years, while in certain species it is missing. It is only when post-maturing has been completed that the seeds can be considered to be of full value from the physiological and practical points of view. The post-maturing of tobacco seeds lasts 2—3 years; during this period the seeds show a fluctuating germination percentage.

The periodicity of dormancy in tobacco seeds is dealt with in three papers by Tsirkovski (1951, 1952a, b), who reports on a 5-year experiment in which the seeds consistently gave low germination percentages between May and September. The author explains the phenomenon by changes in the temperature of the surrounding air and in the relevant vapour pressure. Under dry conditions seed dormancy is prolongued. The germination of tobacco seeds in the light is the subject of papers written by Tammes (1900) and Busse (1925), who found no relationship between seed dormancy and the stimulative effect of light. Mention should be made of the work of Vavilov (1931), who gave proof of the low cold tolerance of tobacco seeds, and that of Gimesi *et al.* (1952), who discuss the chemical aspects of germina-

tion in tobacco seeds. The experiments were aimed at finding out how the viability of tobacco seeds changed during dormancy and what storage conditions exercised favourable effects on the maintenance of germinability.

The tobacco seeds were obtained from the Tobacco Research Institute, Debrecen. The varieties examined were: Kállói 1975—76—77, Kerti 1975—76, Virginia 1974—76 and Coker 1977. The seeds were thus one to five years old at the time of investigation in 1979. Only the 1976 yield could be examined in three successive years.

The seeds were stored in different ways. The 1977 seeds of the variety Kállói were left in the capsules and kept at room temperature. The seeds of the other varieties — a quantity of 200 g each — were put in air-tight bottles with or without 1—2 g silica gel. The bottles with or without 1—2 g silica gel. The bottles were kept at room temperature or placed in a thermostat at 5 °C. Seeds kept at room temperature without gel were regarded as the control. At the special request of the Debrecen Tobacco Research Institute 15 kg seed was placed in a sack in the store-room of the Tápiószele Agrobotanical Centre at 5 °C without any particular protection. The seeds were first germinated every second week, then monthly according to the rules laid down in the Hungarian Standard 6354/68. The investigation was extended to include the correlation between the drying and germination of seeds. Drying took place at a temperature of 25 °C and a relative humidity of 25% for a period of 196 hours; germination tests were performed every 24 hours. The storage of seeds may last for years, in

Table 1a

Results of continuous germination
Variety: Kállói

Year of seed production and year of examination	Method of storage	Percentage germination												Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
		month												
	R	92	90	86	88	89	—	84	88	85	79			85.3
1975	R + g	90	85	91	90	93	—	84	87	82	87			90.0
1978	T	90	89	86	85	93	—	86	89	88	93			83.6
	T + g	86	91	86	90	96	—	82	83	87	86			85.3
1976 1977	R +lg	61	57	60	43	54	44	60	60	54	56	37	59	53.7
	R	47	48	42	41	57	—	62	41	52	52			49.1
1976	R + g	64	70	65	62	63	—	71	56	67	57			63.8
1978	T	64	54	61	63	61	—	66	51	63	45			58.6
	T + g	59	63	59	50	62	—	70	58	51	54			58.4
	R					42	51	57						50.0
1976	R + g					67	62	58						62.3
1979	T					56	59	57						57.3
	T + g					48	37	39						41.3

Note: R = seeds kept at room temperature
R + g = seeds stored at room temperature with silica gel
T = seeds stored in a refrigerator
T + g = seeds stored in a refrigerator with silica gel

which time the seeds age. The physiological state of seeds of various ages was examined by means of a conductometer. 1 g seed was placed in 3 ml distilled water at a temperature of 25 °C. The ions released from the seeds made the water conductive; the conductivity was measured in micro-Siemens (μS). A Radelkis conductometer, an instrument made in Hungary, was used in the experiment. The tobacco varieties were also examined for the heat requirement of germination. This purpose was served by biological thermostats with temperatures rising by 5 degrees from 5 to 30 °C.

1. Continuous germination during post-maturing. Germination was begun in January, when seeds which matured in October were 2 to 2.5 months old. With seeds produced in 1976 the initial germination results were: Kállói 50%, Kerti 90%, Virginia 74%.

Table 1b

Results of continuous germination
Variety: Kerti

Year of seed production and year of examination	Method of storage	Percentage germination												Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
		month												
	R	81	90	74	75	78	84	85	84	87	78	84		81.8
1975	R + g						84	84	88	85	82	93		86.0
1978	T						85	83	87	75	88	90		84.6
	T + g						84	79	82	82	84	80		81.8
	R	88	74	82	85	75	72	77	75	81	83	78	72	78.5
1976	R + g				69			62			79	85	82	75.4
1977	T				77			68			73	83	77	75.6
	T + g				88			70			90	83	82	82.6
	R	69	71	80	80	74	—	77	65	87	85	74		75.7
1976	R + g	83	80	87	83	86	—	80	82	86	79	89		83.5
1978	T	82	74	86	73	86	—	77	76	72	82	71		77.9
	T + g	85	77	82	77	72	—	79	75	76	78	71		77.1
	R					79	84		80					81.0
1976	R + g					77	85		87					83.0
1979	T					68	71		80					73.0
	T + g					78	78		77					77.6
	R					—	—		—					
1975	R + g					83	84		83					83.3
1979	T					75	87		84					82.0
	T + g					84	84		92					86.6

Note: R = seeds kept at room temperature
R + g = seeds stored at room temperature with silica gel
T = seeds stored in a refrigerator
T + g = seeds stored in a refrigerator with silica gel

Table 1c

Results of continuous germination

Variety: Virginia

Year of seed production and year of examination	Method of storage	Percentage germination												Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
		month												
	R	90	93	88	88	86	88	85	91	91	90	88		88.9
1974	R + g	82	90	74	85	94	78	83	82	87	86	83		84.0
1978	T	94	93	89	91	86	90	90	86	80	90	91		89.0
	T + g	89	85	89	89	91	88	87	90	92	88	92		86.0
1976 1977	R	82	77	78	47	56	22	51	54	71	81	72	62	63.1
	R	75	68	67	75	80	75	82	68	80	88			75.8
1976	R + g	86	75	83	67	66	73	89	72	77	70			75.8
1978	T	71	62	31	64	46	47	46	46	72	55			54.5
	T + g	47	47	32	32	33	31	45	59	65	76			46.7
	R					80	80		88					80.0
1976	R + g					75	84		76					78.3
1979	T					60	60		54					58.0
	T + g					55	77		65					65.6
	R					94	89		91					91.3
1974	R + g					85	85		90					86.6
1979	T					89	85		90					88.0
	T + g					91	86		83					86.6

Note: R = seeds kept at room temperature
R + g = seeds stored at room temperature with silica gel
T = seeds stored in a refrigerator
T + g = seeds stored in a refrigerator with silica gel

When germination was repeated monthly the percentages fluctuated (Table 1a, b, c). The fluctuation characteristic of the variety ranged within certain limits: Kállói 40—60%, Kerti 68—88%, Virginia 55—80%. On comparing the fluctuating germination percentages with the initial germination results it can be seen that germination ability neither improved nor worsened over the three years; it merely fluctuated. The fluctuation was much higher in the first year: in the variety Virginia it was 59% in the first year compared to 22% in the second year, while in the other two varieties it was almost identical: 19 and 22% for Kerti and 24 and 22% for Kállói in the first and second years, respectively.

From the results of continuous germination conclusions can be drown on the course of post-maturing. In Fig. 1 the germination line which connects the results shows that the germination percentages of the varieties fluctuate about the initial value. This fact emphasizes the importance of the initial germination percentage. Further, the germination line calls

attention to the necessity of comparing at least two germination results before deciding on the viability of a seed lot. The percentage values obtained at the germination minimum may lead to the seed lot being unfavourably judged, while germination carried out 2—4 weeks later may give the best results. (Certain seed treatments — cooling, application of chemicals — may help in avoiding germination minima.)

Also, the germination line calls attention to the fact that if a series of low germination percentages are obtained for a seed lot, this is indicative of deficient viability, which will not change even under good storage conditions in the case of tobacco seeds. In the present

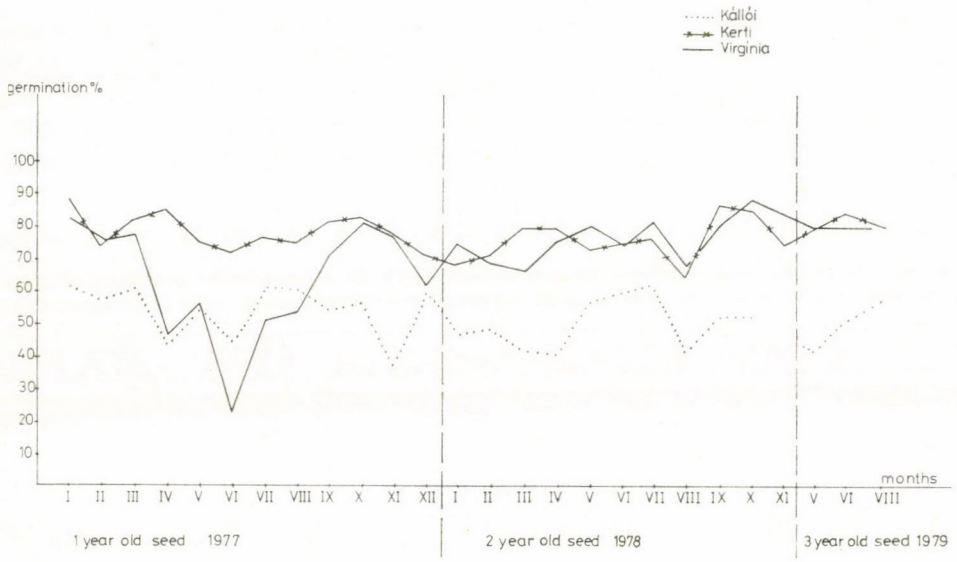

Fig. 1. Results of continuous germination

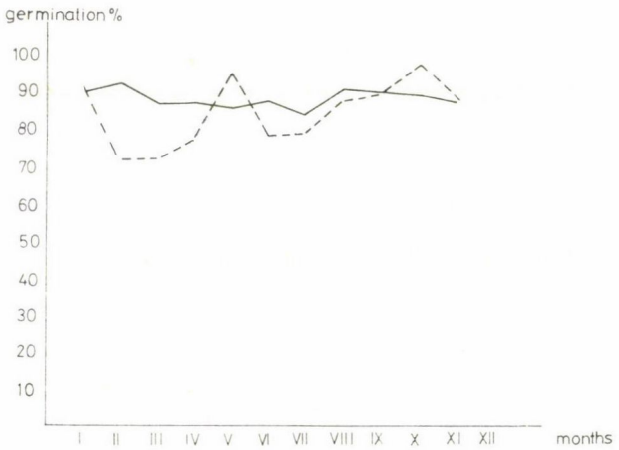

Fig. 2. Results of continuous germination (——— 4 year old seeds of Virginia, – – – – 4 year old seeds of Kállói kept in the capsules)

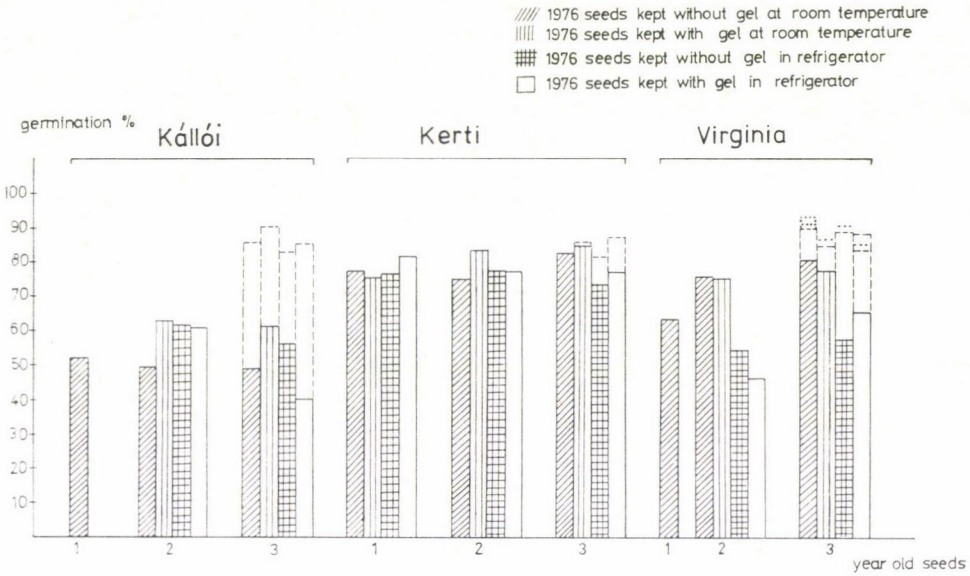

Fig. 3. Effect of storage method on germination of tobacco seeds

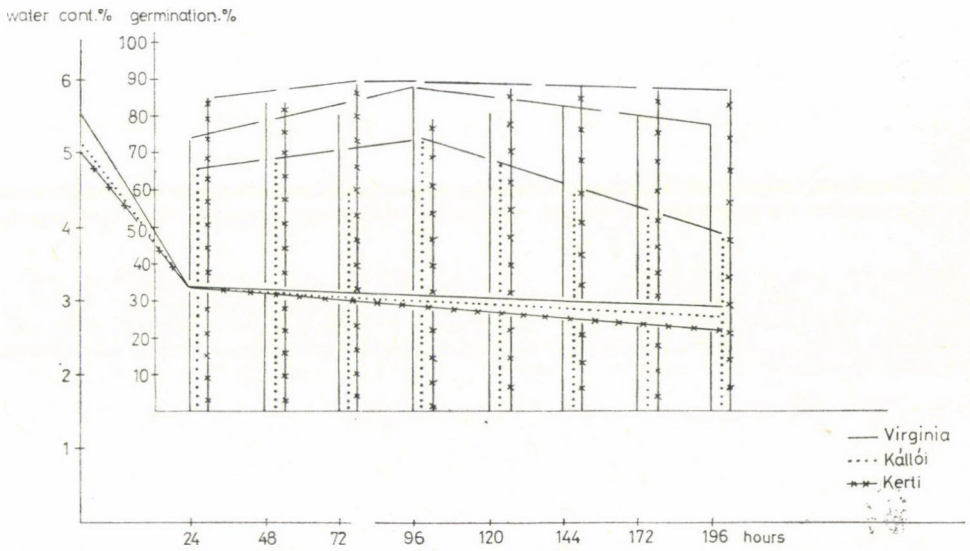

Fig. 4. Relationship between water content and germination of seeds

experiment an example of this was the variety Kállói, which maintained its low germination value throughout the three years.

The above germination results were obtained with seeds produced in 1976. Virginia seeds harvested in 1974 were also germinated for a year in 1978 and the 4-year old seeds gave a germination percentage of 81—93%. The 1977 seeds of Kállói, stored in the capsules,

Table 2

Drying and germination data of tobacco seed
Relationship between water loss during drying and germination

Drying period (hours)	Varieties					
	Virginia		Kállói		Kerti	
	water content	germination percentage	water content	germination percentage	water content	germination percentage
—	5.76	74	5.33	61	5.10	84
24	3.47	74	3.43	67	3.27	85
48	2.96	83	3.13	68	2.73	89
72	2.85	81	3.21	59	2.75	91
96	2.86	89	3.07	74	2.68	81
120	2.36	81	2.86	67	2.60	88
144	2.74	82	2.84	62	2.56	89
172	2.71	80	2.89	50	2.56	86
196	2.74	78	2.87	48	2.50	86

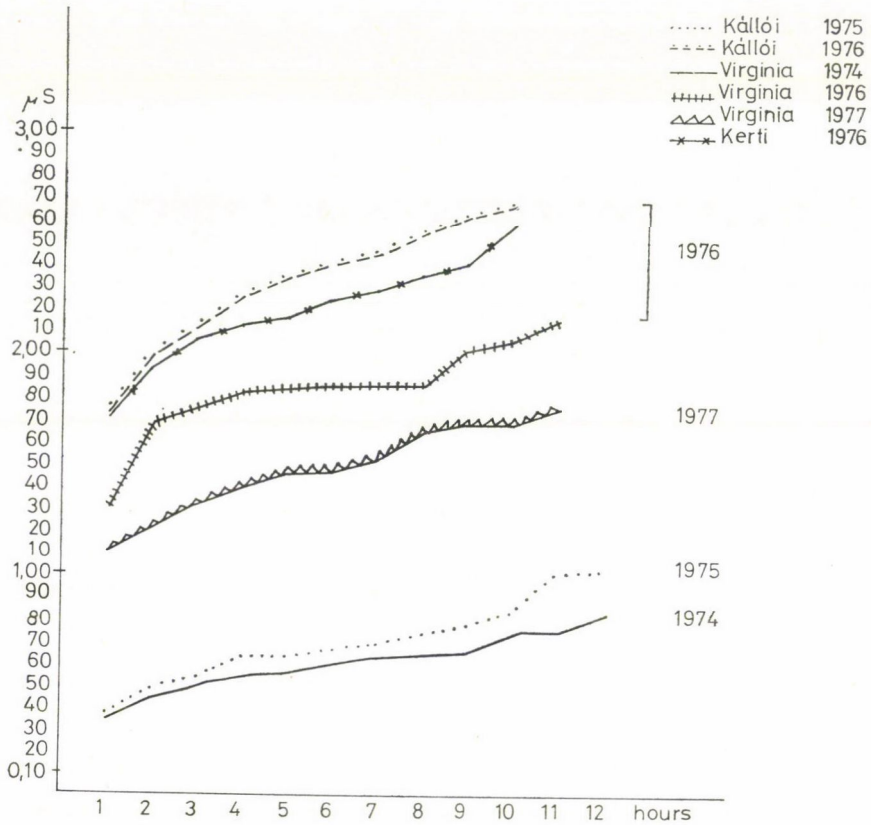

Fig. 5. Conductometric examination of tobacco seeds

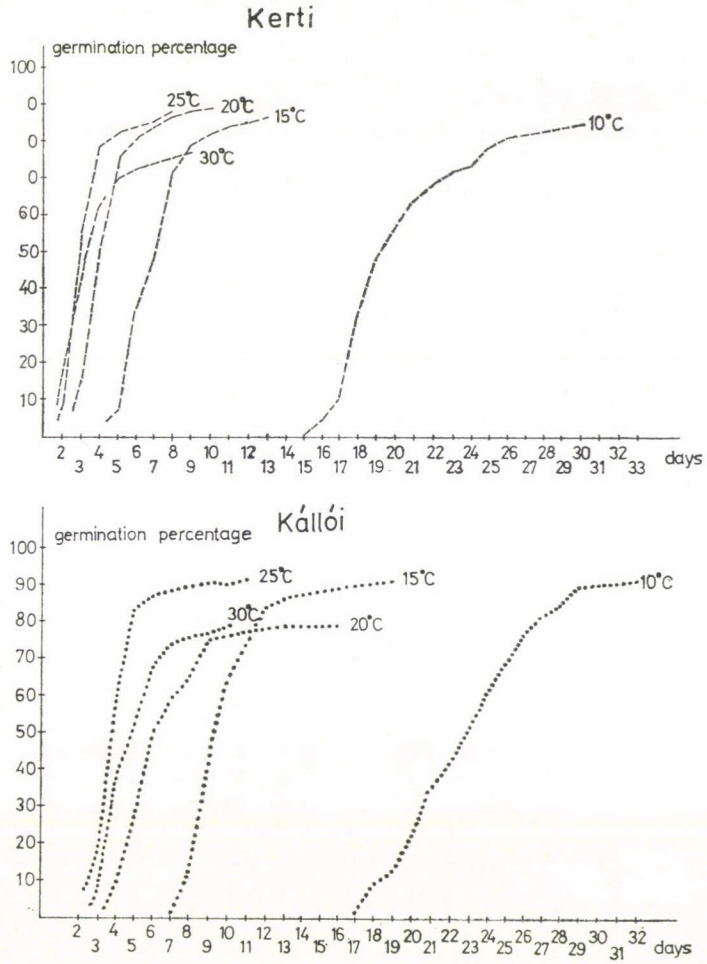

Fig. 6. Germination of seeds at various temperatures for the examined varieties

were also germinated. In 1979 the seeds were 2 years old and gave germination values which fluctuated slightly between 73 and 97% (Fig. 2).

The 15 kg sacked seed, examined for one year, gave a very low germination percentage. After the initial 2.2%, germination was repeated monthly and produced the following results: 15, 12, 3, 30, 10, 67 and 3% respectively. The germination results show that this method of storage is unfavourable for tobacco seeds.

2. Storage method and seed germination. The germination results of seeds kept in the capsule or in cold storage have already been presented in connection with continuous germination. To compare the germination of seeds kept in bottles with or without silica gel, at room temperature or in a thermostat at 5 °C the average percentages of germination carried out yearly and monthly were used. The results, grouped by variety, are contained in Table 1a, b, c, and in Fig. 3.

Seeds of the variety Kállói stored with gel germinated 9—21% better at room temperature than when kept at 5 °C. This result applies to 2—3 year old seeds. With 4 year-old

seeds the difference is 5%. Seeds of the variety Kerti are not affected by the method of storage. Although the germination results for seeds kept in different ways showed a 1—8% difference in favour of seeds kept at room temperature with silica gel, the other methods of storage did not have a harmful effect on the seeds either. The variety Virginia gives a sensitive response to the method of storage. Two or three year old seeds kept at room temperature with silica gel germinated 20% better than those kept in cold storage, and 29% better than seeds kept in cold storage with silica gel.

These observations were made on seeds kept in bottles and can be regarded as the results of a preliminary experiment. They suggest, nevertheless, that storage at 5 °C is unfavourable for tobacco seeds, to an extent varying with the variety.

3. Relationship between seed drying and germination. Under the drying conditions described the original water content of the seed was reduced by about 40% in the first 24 hours. In the second 24 hours the water loss decreased to 0.1—0.2% or ceased completely.

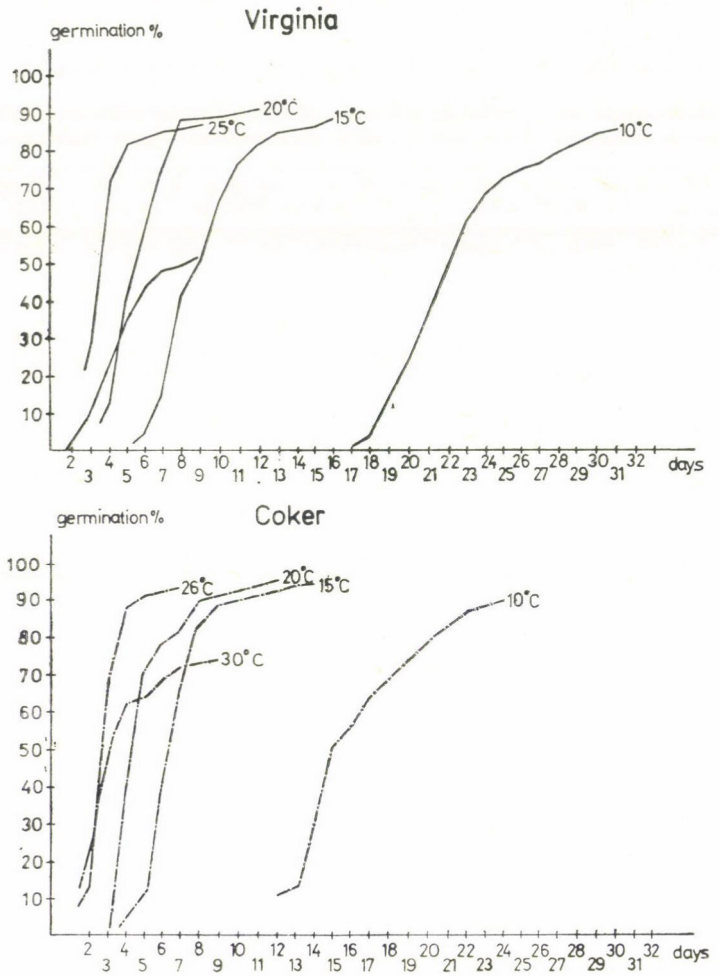

Fig. 7. Germination of seeds at various temperatures for the examined varieties

Table 3

Conductometric examination of tobacco seed

Variety and year of seed production	Method of storage	Conductivity of soaking water in micro-Siemens (μS)											
		1	2	3	4	5	6	7	8	9	10	11	12
		hours											
Kállói 1975	R	0.41	0.50	0.55	0.58	0.62	0.65	0.69	0.73	0.78	0.82	0.86	1.09
	R	0.32	0.46	0.57	0.66	0.67	0.71	0.73	0.80	0.84	0.92	0.93	1.20
	R + g	0.44	0.53	0.57	0.64	0.66	0.71	0.73	0.78	0.82	0.87	0.94	1.20
	T	0.36	0.44	0.51	0.56	0.59	0.61	0.65	0.67	0.71	0.78	1.10	1.25
	T + g	0.41	0.48	0.54	0.66	0.61	0.62	0.67	0.71	0.77	0.80	1.16	1.19
	Mean	0.38	0.48	0.54	0.62	0.63	0.66	0.69	0.73	0.78	0.83	1.00	1.18
Kállói 1976	R	1.85	2.00	2.07	2.20	2.22	2.33	2.38	2.45	2.58	2.70		
	R + g	1.33	1.45	1.52	1.57	1.67	1.76	1.77	1.85	1.81	2.00		
	R	1.48	1.98	2.19	2.42	2.50	2.53	2.56	2.74	2.80	2.90		
	T	2.00	2.25	2.37	2.51	2.63	2.70	2.77	2.83	2.90	2.90		
	T + g	1.89	2.25	2.37	2.51	2.63	2.71	2.85	2.92	2.97	2.80		
	Mean	1.71	1.98	2.10	2.24	2.33	2.40	2.45	2.55	2.61	2.66		
Kerti 1976	R	1.68	1.75	1.82	1.88	1.95	1.98	1.98	2.08	2.10	2.38		
	R + g	2.02	2.19	2.21	2.31	2.33	2.37	2.50	2.51	2.59	2.96		
	T	2.10	2.27	2.31	2.35	2.41	2.42	2.46	2.59	2.61	2.70		
	T + g	1.31	1.73	1.91	2.00	2.02	2.09	2.16	2.23	2.26	2.35		
	Mean	1.70	1.96	2.06	2.13	2.18	2.22	2.29	2.36	2.40	2.58		
Virginia 1974	R	0.52	0.52	0.62	0.62	0.65	0.66	0.67	0.70	0.75	0.94	0.95	0.96
	R	0.31	0.47	0.50	0.52	0.53	0.57	0.63	0.66	0.67	0.71	0.72	0.83
	R + g	0.51	0.56	0.58	0.60	0.66	0.69	0.73	0.75	0.75	0.78	0.80	0.92
	T	0.28	0.48	0.45	0.48	0.51	0.57	0.57	0.60	0.62	0.63	0.73	0.74
	T + g	0.25	0.43	0.46	0.48	0.51	0.53	0.53	0.53	0.54	0.58	0.64	0.65
	Mean	0.37	0.49	0.52	0.54	0.57	0.60	0.62	0.64	0.67	0.73	0.73	0.79
1976	R	1.42	1.66	1.77	1.80	1.77	1.76	1.81	1.75	2.05	2.08	2.10	
	R + g	1.70	1.75	1.84	1.85	1.85	1.86	1.87	1.87	1.82	1.94	2.22	
	T	1.29	1.57	1.62	1.80	1.85	1.94	1.95	2.01	2.04	2.09	2.15	
	T + g	0.99	1.71	1.78	1.82	1.82	1.82	1.83	1.81	1.92	1.92	1.92	
	Mean	1.30	1.67	1.75	1.81	1.82	1.84	1.86	1.86	1.91	2.07	2.16	
1977 in capsule	R	1.10	1.20	1.31	1.40	1.48	1.48	1.52	1.56	1.60	1.60	1.68	

Note: R = seeds kept at room temperature
R + g = seeds stored at room temperature with silica gel
T = seeds stored in a refrigerator
T + g = seeds stored in a refrigerator with silica gel

After 120 hours of drying the seeds reached equilibrium with the humidity of the environment and no longer lost any water (Table 2 and Fig. 4).

In the varieties Virginia and Kerti drying had no unfavourable effect on seed germination. Germination in the variety Kállói fluctuated considerably during drying; the germination percentage also decreased and the seeds were slow to lose their water contents.

According to the results the seeds of the varieties examined can be dried to a water content of 2.8—3.0% without any decrease in their germinative ability. The water content

Table 4

Seed germination at various temperatures

Variety	Temperature, °C	Beginning of germination (days)	Daily percentage of germination															Total, %
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
			days																
Kállói	10	17	1	9	12	13	8	9	9	7	8	6	2	6	1				91
	15	7	1	12	33	18	10	9	3	1	1	1	1						90
	20	5	8	19	22	9	7	10	1	1	1	1	1						80
	25	3	18	41	22	6	2	1	1										*91*
	30	3	7	16	15	15	15	6	2	1	1								78
Kerti	10	15	1	5	5	21	15	9	8	5	3	2	5	2	1	1	1	1	85
	15	5	8	27	13	23	8	3	2	2	1								87
	20	3	15	37	23	6	3	3	1	1									*89*
	25	2	9	46	24	3	2	1	1										86
	30	2	13	34	14	9	3	1	—	1	1								76
Virginia	10	17	1	3	9	11	13	12	12	7	5	2	2	3	2	3	1		86
	15	6	4	10	26	10	15	11	6	3	1	1	1						88
	20	4	12	28	19	15	14	—	1	1	1								*91*
	25	3	27	45	9	3	1	1	—	1									87
	30	3	2	9	10	14	8	5	1	1	1								51
Coker	10	13	10	3	16	21	5	8	6	4	5	4	4	2	1				89
	15	4	4	7	29	27	15	6	1	1	2	1	1						*94*
	20	3	2	38	30	8	4	8	1	1	1	1							*94*
	25	2	13	54	21	3	1	1											93
	30	2	17	37	7	3	4	3	1	1									73

in seeds of Kállói, a variety more sensitive to drying, can only be reduced to 3%, because any further loss of water would involve a decrease in germination.

4. Conductometric examination of tobacco seeds. The conductometric examinations were aimed at finding out whether the conductivity of the water in which the seeds were soaked changed as the seeds aged (Fig. 5). In addition, the influence of the method of storage on the course of ageing was examined (Table 3). The examination was carried out in 1978 when the 1975 and 1974 seeds were 3 and 4 years old, respectively. Their conductivity then reached a value of 1 μS. The conductivity of the soaking water was 2.5 μS for 2 year old seeds from 1976, and 1.5 μS in the case of 1977 seeds kept in the capsules. These results were obtained after soaking the seeds for 10—12 hours.

According to previous investigations by the authors, in the case of starch-containing seeds the soaking water of older seeds shows a higher conductivity than that of fresh seeds. With tobacco seeds it is the other way round: the soaking water of older seeds has lower conductivity. The conductometric examination could be suitable for making a rough estimation of the age of individual seed lots, as already shown in conductometric examinations on lentil and tobacco seeds (PAPP 1979).

5. Germination of tobacco seeds at various temperatures. The results of this experiment are summed up in Table 4 and Fig. 6—7 and confirm what the Hungarian Standard 6354/68 establishes, namely, that 25 °C is the optimum temperature for the germination of tobacco seeds. For the variety Kerti 20 °C may also be regarded as optimum, since at that temperature the seeds of this variety germinate well — with a difference of +3%. Virginia is a much more sensitive variety. At 20 °C only 59% of the seeds germinated in the first 3 days, while at a 5 °C higher temperature this figure was 81%. The variety Kállói is also sensitive; the proportion of seeds germinating in 3 days was 49% at 20 °C and 81% at 25 °C. In the variety Coker the germination of the seeds was 18% better at 25 °C than at 20 °C.

If the final results of germination are considered the differences in germination percentage are found to be negligible, but the germination results of the first 3 days emphasize the difference. At 30 °C the germination decreased in all the varieties examined.

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EFFECTIVENESS OF DIRECT AND INDIRECT SELECTION ON FEED CONVERSION AND BODY WEIGHT GAIN OF BEEF BULLS

A number of earlier and recent investigations have proved that feed conversion is a highly important factor for economic beef production (KRÄUSSLICH 1973, LEUTHOLD *et al.* 1976, CARTER 1979). For this reason, in the last decade breeding aimed at improving feed conversion has been placed in the focus of scientists' interest and research.

ZADRAVEC—FERCEJ (1973), LÜKE (1975) and BODA (1979) have reported that the phenotypic variance of feed conversion is fairly wide and in some cases considerably exceeds that of the body weight gain. High phenotypic variance is one of the preconditions for the effectiveness of selection. Rittmannsperger (cit. KRÄUSSLICH 1973) and LEUTHOLD *et al.* (1976) have pointed out that the variance of feed conversion shows an upward tendency on increasing the feeding level and advancing the fattening. This statement directs attention to the relations between the type of young fattening cattle and their feed conversion. The results of various investigations on the heritability of feed conversion are summarized in Table 1. According to the h^2-values presented here, feed conversion is a trait with moderate heritability.

The high phenotypic variance and moderate heritability of feed conversion raise the hope that feed conversion may be improved by breeding. According to the general opinion existing in professional circles, this is not only possible but also necessary. However, there is a definite difference of opinion with respect to whether the estimation of the breeding value of sire candidates should be extended to include feed conversion as an independent selectional trait, or whether it would be satisfactory to base selection on body weight gain only (because of the correlation between the traits in question).

Owing to the mostly moderate, and in some cases close relationship between body weight gain and feed conversion (Table 2), until quite recently it was the general opinion that feed conversion ability should not be taken into consideration in selection as an independent trait, because selection based on body weight gain leads indirectly to genetic improvement in the feed conversion, too. However, recent investigations have thrown light both upon the higher economic importance of feed conversion compared to earlier estimations and upon the fact that the relationships are in many cases not close enough and often statistically insignificant (BAILEY *et al.* 1971), so that the feed conversion could not be improved

Table 1

Efficiency of direct and indirect selection for starch value conversion and for body weight gain by selecting the best 10 and 20% of the population

Basis of selection	% of population	Efficiency of selection			
		Starch value/1 kg body weight gain		Body weight gain	
		kg	%	kg	%
1. Starch value conversion	0—10	3.19	100	485	92
	10—20	3.38	100	478	93
	0—20	3.28	100	482	93
2. Body weight gain	0—10	4.05	127	526	100
	10—20	3.97	117	512	100
	0—20	4.01	122	519	100

for a long time by indirect selection. According to the findings of KRÄUSSLICH (1973) intensive selection leads to a continuous change in the correlation circumstance, however close they are. Therefore, the correlations not only have to be revised time and again, but breeders should not rely fully upon them.

Papers published during the last 7—8 years suggest that most of the well-known authorities on cattle breeding value estimations are in full agreement that the breeding value estimation of sire candidates intended for beef production should be extended to include feed conversion (RITTMANNSPERGER 1972, KRÄUSSLICH 1973, LINDQUIST 1975, ZUPP—NEUMANN 1975, BROWN 1976, SOUTHGATE 1976).

The aim of this investigation was to contribute some data to the questions raised above. By calculating rank correlation coefficient and by simulating selection investigations have been made on:

— the relationship between body weight gain and starch value conversion, and
— the effectiveness of direct and indirect selection on starch value conversion and body weight gain.

In accordance with the objectives outlined above the investigations comprised data collected on 111 young Hungarian Spotted fattening bulls. All the bull calves were born and reared on one large-scale state farm and were fed according to an identical feeding regime and technology. From 90 days' age onwards the weaned bull calves were fattened (kept and fed) individually in the same state farm, till the achievement of a uniform 600 kg slaughter weight. Over the whole fattening period maize silage was fed ad libitum with supplemental concentrate and moderate (1—2 kg) hay rations, depending on the nutrient requirements of the animals.

In order to clarify the relationship between body weight gain and starch value conversion, the young fattening bulls were first ranked on the basis of each trait, then the consonance or divergence between rank orders was examined by calculating rank correlation. The coefficient of rank correlation between the traits was $r_{rank} = 0.46$. This figure indicates that the relationship between the traits is not very close, i.e. when selecting sire candidates, there is only a moderate probability that the same individuals will be superior for both traits. This statement deserved attention primarily for the selection of sire candidates, i.e. top individuals, sine it raises the general question of whether any of the economically important traits (the starch value conversion in this case) could be left out of consideration in the selection of sire replacers, because of the correlations that prevail among the production traits.

In order to make clear the differences in the starch value conversion and body weight gain of the selected top individuals depending on whether direct or indirect selection was used, a simulated selection was carried out. Based on either starch value conversion or body weight performances shown at 15 months of age, the best 10% (0—10%), the second 10% (10—20%) and the best 20% (0—20%) of the animals were selected and their starch value conversion and body weight gain was investigated. These results are presented in Table 1.

In the first section of the table starch value conversion was taken as the basis for selection. Accordingly the data given here represent the results of direct selection for starch value conversion and indirect selection for body weight gain. Conversely, in the second section of the table the results of indirect selection for starch value conversion and direct selection for body weight gain are illustrated.

These figures demonstrate the great differences between the results of direct and indirect selection. When simulating direct selection for starch value conversion the effectiveness of selection was superior by 27% for the best 10% of animals and by 17% for the second 10% of animals, in comparison to the results of groups selected directly on the basis of body weight gain. As far as body weight gain is concerned, direct selection for starch value conversion resulted in 8 and 7% less gain in the groups mentioned above.

The results of both rank correlation estimates and simulated selection support the opinion that selection based on body weight gain alone is insufficient in the top breeding category for the simultaneous and effective improvement of feed conversion. In the selection of young bulls as sire candidates both body weight gain and feed conversion performances have to be taken into consideration.

In accordance with this statement the question arises, whether extending the breeding value estimation to include feed conversion is successful only as a breeding aim or also from the economic point of view, since it requires individual measurements of weight, weight gain and feed consumption. Thus, the measurement of individual feed conversion is highly laborious and requires costly facilities.

This question has to be examined according to existing circumstances. The model calculations of SKJERVOLD (1977) suggest that the expenditure of measuring individual feed conversion within the breeding value estimation will be abundantly recovered.

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MONOSOMIC ANALYSIS OF STEM RUST RESISTANCE IN ADULT PLANTS OF THE WINTER WHEAT VARIETY ARTHUR

Wheat breeders often use the variety Arthur as a source of resistance to stem and leaf rust and powdery mildew. It is mostly used for crossing in countries where the danger of infection by yellow rust is low, or the pathogen does not occur at all.

The wide-spread use of this variety encouraged the authors to try to locate the genes carrying seedling resistance to race 11 of stem rust, the race most common in Hungary. Subsequently, the variety was examined for its seedling response to a mixture of the three races of stem rust (11, 218, 331) most frequently encountered in Hungary in the year 1978. The results showed that the genes responsible for seedling resistance to stem rust in the variety

Arthur were located in chromosome 3B in the first case, and in chromosomes 1A, 3B and 3D in the latter (BEDŐ *et al.* 1979).

The present paper deals with the inheritance of stem rust resistance in adult plants of the variety Arthur, and investigates whether there is any relationship between seedling resistance and resistance in the mature stage.

With this in view, all 21 monosomic lines and the disomic form of Chinese Spring were crossed with Arthur. After a cytological analysis of mitotic division in the root tip, the monosomic F_1 seedlings were planted out in the nursery, and the ears were isolated. To check

Table 1

Segregation ratios in the F_2 generation of monosomic lines of Chinese Spring × Arthur in response to infection by five stem rust races in the adult plant stage

Cross	1979			1980		
	Number of plants		χ^2 15 : 1	Number of plants		χ^2 15 : 1
	resistant	susceptible		resistant	susceptible	
CS 1A × Arthur	152	2	6.44*	191	4	5.87*
CS 2A × Arthur	130	13	1.97	154	19	6.61*
CS 3A × Arthur	135	10	0.10	169	13	0.25
CS 4A × Arthur	150	15	2.27	181	18	0.66
CS 5A × Arthur	131	10	0.17	93	11	3.32
CS 6A × Arthur	132	17	6.77**	173	14	0.49
CS 7A × Arthur	143	15	2.84	170	13	0.23
CS 1B × Arthur	133	10	2.69	166	14	0.68
CS 2B × Arthur	134	2	5.30	157	2	6.76**
CS 3B × Arthur	113	10	0.74	164	15	1.39
CS 4B × Arthur	95	11	3.08	109	9	0.38
CS 5B × Arthur	132	10	0.15	124	14	3.57
CS 6B × Arthur	93	10	2.10	108	16	9.37**
CS 7B × Arthur	141	17	5.48*	161	26	18.70***
CS 1D × Arthur	133	21	14.34***	159	31	32.85***
CS 2D × Arthur	129	8	0.04	152	16	3.07
CS 3D × Arthur	140	10	0.04	160	13	0.47
CS 4D × Arthur	136	9	0.01	152	19	6.90**
CS 5D × Arthur	126	9	0.04	172	14	0.52
CS 6D × Arthur	122	9	0.09	162	22	10.23**
CS 7D × Arthur	131	11	0.54	160	14	0.96
CS 42 × Arthur	140	12	0.28	182	18	2.58
Chinese Spring	0	100	—	0	100	—
Arthur	100	0	—	100	0	—

* P = 0.05 ** P = 0.01 *** P = 0.001

the results of mitosis, an analysis of meiosis was also performed. Part of the harvested grain yield was used for testing seedling resistance to stem rust. After the completion of the experiment, leaves infected by stem rust were removed from the plants, vernalized for 40 days, then in the spring of 1979 planted out in the nursery. The plants were infected with a mixture of three races of stem rust (11, 218, 331). The stem rust infection was evaluated using the method described by STAKMAN *et al.* (1962). The following year, in 1980, seedlings obtained from the remainder of the F_1 grain yield were vernalized in the same way and then planted out. The infection was induced with a mixture of the stem rust races 1, 11, 34, 218 and 331. An evaluation was made using the same method as in the previous year.

To reveal the causes of changes in resistance, the F_2 seedlings of the 3B, 3D and disomic lines were also tested simultaneously, with a mixture of the five races of stem rust listed above, both before and after vernalization.

Prior to discussing the results obtained it should be noted that in spite of the fact that the inoculation was carried out with three races of stem rust, in 1979 five races were isolated from the plants. These were the races 1, 11, 34, 218 and 331, i.e. those used in the 1980 experiment. In the latter experiment no stem rust races other than the five races mentioned were encountered.

The repetition of the experiment was aimed at determining whether or not the infection of seedlings in the first year brought about any degree of "immunity" in the adult plants.

Table 2

Segregation ratios in the F_2 generation of two monosomic lines of Chinese Spring × Arthur in response to infection by five stem rust races at the seedling stage

Cross	Number of inoculated plants			15 : 1*
	resistant	inter-mediate	suscep-tible	
Before vernalization				
CS 3B × Arthur	107	48	12	0.25
CS 3D × Arthur	96	52	9	0.07
CS 42 × Arthur	86	20	10	1.11
Chinese Spring	0	0	50	—
Arthur	50	0	0	—
After vernalization				
CS 3B × Arthur	27	127	10	0.01
CS 3D × Arthur	33	120	14	1.19
CS 42 × Arthur	41	129	13	0.23
Chinese Spring	0	0	60	—
Arthur	60	0	0	—

Type of response: resistant: 0, 0; 1
intermediate: 2, 2+ (x type could not be observed)
susceptible: 3, 4
* Resistant + intermediate: susceptible = 15 : 1

The results prove (Table 1) that in both cases chromosomes 1A and 2B are responsible for field resistance to stem rust in the variety Arthur. At the same time, the behaviour of the chromosomes 2A, 6A, 6B, 7B, 1D, 4D and 6D was significantly different in the two experiments.

When comparing resistance at the stage of maturity to seedling resistance considerable differences were found. Genes for resistance in the adult plant stage are carried by the 1A and 2B, instead of the 1A, 3B and 3D chromosomes. At the same time, in the seedling stage the source of resistance to 3 races is found in 2 chromosomes. The other difference was, that while in the course of seedling tests the plants were found to fall within three categories (resistant, intermediate and susceptible), adult plants could be divided into two groups (resistant and susceptible) in both years.

The diverse results may be due to a difference in the mechanism of resistance in the seedling and adult plant stages, but may also be caused by the changed race composition. To settle this question another experiment was set up with the monosomic lines 3B and 3D in such a way that infection with all the five races was induced in the seedling stage before and after vernalization. According to the results (Table 2) the plants can be placed in three categories in this case too. The results for the disomic line suggest a digenic segregation. None of the monosomic lines gave a significant deviation from the 15 : 1 segregation ratio, i.e. the genes responsible for resistance to the three races proved ineffective in this case. Thus, the diverse results can partly be explained by the different race composition, but this neither excludes nor confirms the difference or similarity of resistance at the seedling and adult plant stages.

The proportion of susceptible plants obtained when infection was induced before and after vernalization was the same in every case. However, intermediate plants were found in considerably larger numbers and resistant ones in much smaller numbers after vernalization than prior to it. The response of the variety Arthur showed a similar trend: 1, 0; 0 in the former and 0, 0; 1 in the latter case.

In chromosome 2B, which plays a role in developing resistance in the mature stage, it seems that the gene Sr 9c is to be found. This gene originates from *Triticum timopheevi* (Sears—Loegering 1968) and may have been introduced into the variety Arthur through CI 12633. On chromosome 1A a gene transmitting resistance to races 21 and 34 was demonstrated by Jha (1970a, b) in seedlings of the variety Sonora 64, while Singh—Swaminathan (1960) determined a recessive factor responsible for seedling resistance when inoculating plants of the variety N.P. 790 with race 15c. This latter is definitely not identical with the resistance gene found in the 1A chromosome of Arthur, but further investigations will be required in connection with the gene demonstrated by Jha.

*

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MYOSIN WITH INCREASED P CONTENT IN THE MUSCLES OF EXERCISED HORSES

It was earlier found (FAZEKAS—SZÉKESSY-HERMANN 1977) that the myosin isolated from the *m. long. dorsi* of chinchilla using the given method of preparation had a fairly constant (12 mol) phosphorus content, while the P content in the homologous muscular myosin of its wild ancestor (rabbit) was higher than this: 13—16 mol (FAZEKAS *et al.* 1979c, FAZEKAS *et al.* 1979b). This suggested the idea that the phosphorus content of myosin might be related to contraction and to the capacity of the muscle. To confirm this supposition the muscles of an exercised horse (used for jumping) were examined.

From earlier comparative studies it is known that with solutions containing NaCl myosin with a higher P content can be obtained from the muscles of both chinchillas and rabits than with solutions containing KCl (FAZEKAS *et al.* 1980). Therefore, the same method was followed in the present study.

An answer was sought to the question of whether the P-lipid content in myosin containing larger quantities of phosphorus was actually higher than that found in rabbit muscle preparations. The results were expected to solve questions of decisive importance from the point of view of judging the functioning and degree of training of the muscle. Nor is it a matter of indifference whether the "preparative P content" in the NaCl-myosin of exercised horse muscles can be increased by phosphorylation in the same way as it can in chinchilla myosin preparations (FAZEKAS *et al.* 1979a).

Of the synthetic amino acid phosphates, P-Arg — commercially purchased from Calbiochem. AG, Switzerland — was synthesized with the technique of MARCUS—MORRISON (1964), while N-ε-P-Lys was synthesized by the method of ZETTEROUIST—ENGSTRÖM (1967). N^{π}-P-His and N^{τ}-P-His were synthesized after HULTQUIST (1968). By choosing the right concentrations of the initial materials it proved possible to perform an oriented synthesis (FAZEKAS *et al.* 1976).

The following materials were used: DTT, histamine dihydrochloride and D,L-α-tocopherol from Calbiochem; DTNB from Fluka; DEAE-cellulose (Whatman DE_{52}), Dextran blue, serotonin sulphate, Bradykinin triacetate, cAMP, cGMP and TNBS from Serva, Switzerland; LVP from Sandoz, Switzerland; Sepharose 4B (CL-4B) from Pharmacia; EGTA from Fisons, England; PGF_{2d} and Fixion D 50 X8 fertigfolien ion exchange for TLC from Chinoin, Budapest; ATP from Reanal, NA Richter, Budapest; HNO_3, H_2SO_4 and ammonium molybdate from Merck, Darmstadt; analytic grade TRIS, KCl, NaCl, $KHCO_3$ and $NaHCO_3$ from Reanal, Budapest.

The muscle samples were excised in the slaughterhouse from *m. long. dorsi* and *m. rectus femoris* and transported in ice. Cleaning was carried out at 0—4 °C in every case. The dry matter content and total P content were determined in samples of 20—50 mg, while the bulk of the muscles was ground in a precooled mincing machine and measured gravimetrically.

The mince was homogenized with 3 volumes of NaCl-containing extraction solution (FAZEKAS *et al.* 1980) in a Beckman homogenizer (at 3000 rpm for twice 10 seconds). After a short extraction period the homogenate was centrifuged within 10 minutes (5000 g, 20 min).

The volume of the supernatant was measured, then diluted 14-fold with ice-cooled distilled water. The transparent upper phase above the myosin flakes was decanted and the precipitate was collected by centrifugation (5000 g, 20 min). Further purification was carried out as described earlier (FAZEKAS *et al.* 1979a, FAZEKAS *et al.* 1980), except that the last phase of purification was slightly modified.

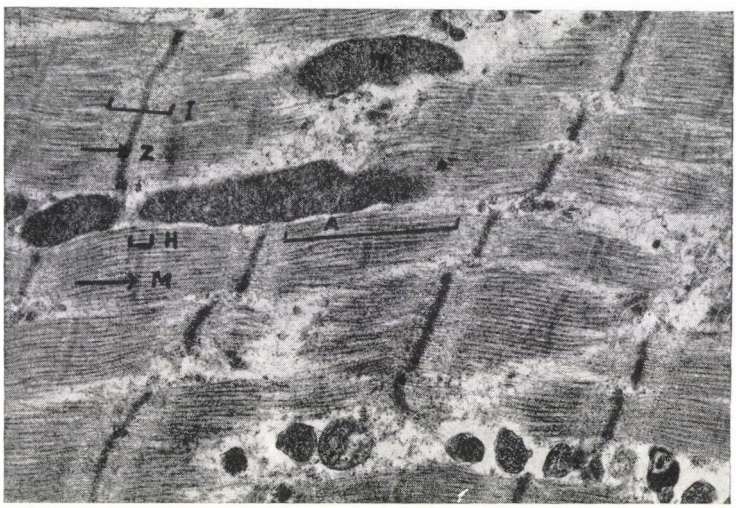

Fig. 1. Electron microscopy of thin section of horse back muscle *(m. long. dorsi)* prepared as described in the text. Magnification about 10,000×

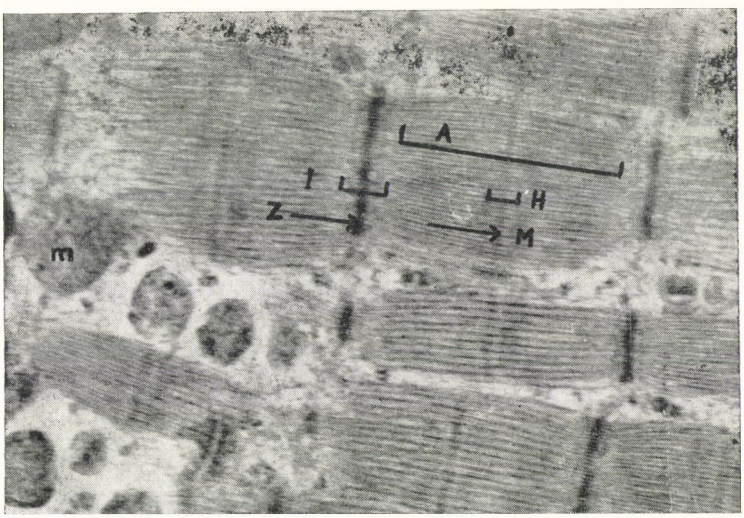

Fig. 2. Electron microscopy of thin section of horse thigh muscle *(m. rectus femoris)*. Magnification about 10,000×

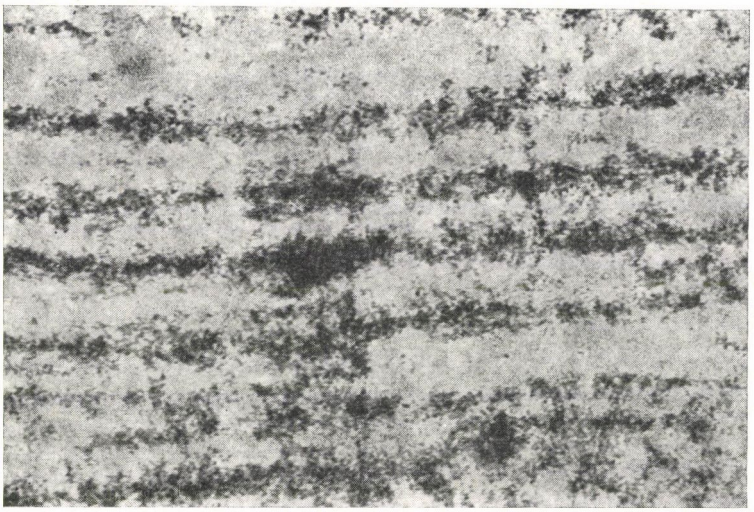

Fig. 3. Electron microscopy of ultrathin section of horse thigh muscle. Section was obtained from the middle of sarcomer with M-line in the centre (shown in Fig. 2). Magnification about 100,000×

Before being ultracentrifuged (105,000 g, 90 min) the myosin solutions were treated with DEAE-cellulose and the concentration of NaCl was adjusted to 0.38 mol. The DEAE-cellulose treatment removes the associated RNA, P-lipid and other protein traces from the myosin. Purification was completed by gel filtrating the myosin on a Sepharose 4B column (Figs 4, 5). In the subsequent experiments the fractions indicated in the figure were used.

The protein content of the myosin was determined with the microbiuret method described by GOA—SCAN (1963), or calculated by measuring the UV absorption; the protein contents of lipid- and salt-free preparations (FOLCH *et al.* 1957) were established by the gravimetrical measurement of the dried residues gained at 105 °C.

The P content was measured in fresh and dried tissue samples as well as in gel-filtrated, lipid- and salt-free, control, phosphorylated, etc. preparations of myosin. In the inorganic residues of the samples (obtained by reducing them to ashes in the presence of HNO_3) the P content was determined with the method of FISKE—SUBBAROW (1925), but the final colour was developed by ascorbic acid reduction after LOWRY *et al.* (1954).

The phosphorylation of myosin and the removal of the superfluous nucleotide and adsorbed Pi were carried out in the manner described in an earlier paper (FAZEKAS *et al.* 1979a).

The effects of several hormone and Arg, Lys and His reagents on the phosphorylation of myosin were examined. The concentrations are shown in Table 4. The reagents were added to the reaction mixture containing myosin before phsphorylation, so as to enable the interaction to develop.

The RNA (and nucleotide) contents of the myosin were determined on the basis of ribose analysis by the method of SCHNEIDER (1957), and the actual P content was calculated using an RNA correction.

Abbreviations used: DEAE — diethylaminoethyl; DTT — dithio-threitol; DTNB — 5,5'-dithiobis-(2-nitrobenzoic acid); EGTA — ethylene glycol bis-(2-aminoethyl) tetraacetic acid; TNBS — 2,4,6-trinitrobenzene sulphonic acid; NA — L-norepinephrine; LVP — lysine-vasopressin; TRIS — Tris-(hydroxymethyl) aminomethane; $PGF_{2\alpha}$ — prostaglandin $F_{2\alpha}$; HC — heavy chain; LC — light chain.

The labile P content is released to a different degree under the influence of H^+ ions, diethyl pyrocarbonate, hydroxyl-amine, 2,3-butanedion, phenyl-glioxal, TNBS and Cu ions. The transitional metals, Cu^{2+}, and also Zn^{2+} and Co^{3+}, form very stable complexes with histidine and its peptides, which are suitable for chromatography (BAGGER *et al.* 1972).

The release of the labile P content was carried out according to the method described by MARKLEY *et al.* (1977) from 2 ml samples in a 0.5 mol KCl—0.05 mol Tris-HCl (pH 7.4)

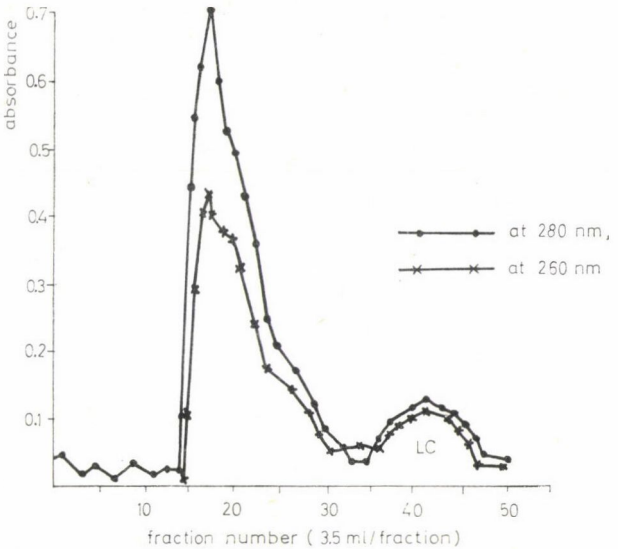

Fig. 4. Gel-filtration of horse skeletal muscle myosin on Sepharose 4 B column (1.8 × 71 cm). The myosin was prepared from the back muscle *(m. long. dorsi)* of the horse; 60 mg myosin in 5 ml final volume was applied to the column. The column was equilibrated with 0.5 M NaCl, 5 mM $KHCO_3$ and 0.1 mM DTT, and 3.5 ml fractions were collected. The flow rate was 12 ml/h

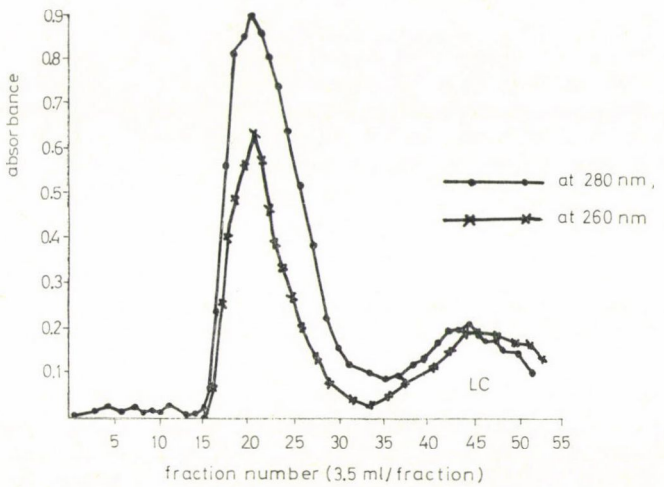

Fig. 5. Gel-filtration of myosin from *m. rectus femoris* on the same Sepharose 4 B column; 46 mg myosin in 5 ml total volume was applied to the column. Other details as described for Fig. 4

buffer giving a final concentration of 1 mmol with the application of $CuCl_2$ treatment. The amino acid phosphates of myosin were separated from alkaline hydrolysates of gel-filtrated or phosphorylated myosin samples from which the lipids had been removed. The gel-filtrated myosin was precipitated with acetone, followed by the removal of lipid and salts, and the protein part was hydrolysed with 3 mol KOH at 105 °C for 8—12 hours in sealed ampoules made of pyrex borosilicate glass and used at least ten times. The hydrolysate, diluted to 0.01 mol KOH, was applied to a 0.9×6 cm Dowex 1×8 column. The amino acid phosphates were separated by $KHCO_3$ linear gradient chromatography. Fractions of 3.5 ml were collected and a 0.5 ml aliquot of each fraction was used to determine the P content. Only tubes giving a positive ammonium molybdate reaction were collected. In lyophilized samples of the collected fractions the presence of Arg, Lys and His was pointed out by their specific reactions. Owing to the Si background the identification of basic amino acid phosphates requires great care (FAZEKAS *et al.* 1981). After further concentration (by lyophilization) using the method described above the amino acid phosphates in the individual fractions were identified by paper chromatography, and the free amino acids with the TLC technique after Pi had been released (with $HClO_4$), according to the method of SAJGÓ—DÉVÉNYI (1972).

For the electronmicroscope examinations pieces of muscle were fixed in 5% glutaraldehyde dissolved in Millonig buffer for 1.5 hours at +4 °C. Post-fixation was carried out at +4 °C with 1% osmium tetroxide for 1 hour. Dehydration was carried out with ethanol, and Durcupan ACM (Fluka) synthetic resin was used for embedding. Ultra-fine sections were made by means of a Reichert Om U2 ultramicrotome. The thin sections were stained with uranyl acetate and lead citrate and were examined using a Jeol electronmicroscope. For the light microscope examinations half-thin sections were prepared and stained with toluidine-blue.

In the course of electronmicroscope examinations no characteristic difference was found between the two muscles in the filamentary system (Figs 1, 2).

Magnification clearly showed the paired arrangement of the heads of the myosin molecules in the thick filaments (Fig. 3).

From the last phase of myosin purification the gel-filtration is illustrated for the individual muscles. Gel-filtration of the myosin from *m. long. dorsi* is shown in Fig. 4, and that from *m. rectus femoris* in Fig. 5.

Besides the myosin a minor peak is seen in the low molecular weight region (around 15—40 thousand dalton → 15—40 kDa) in both figures. According to the results of electrophoresis on SDS-polyacrylamide gel, a mixture of the three LC fractions of myosin is mainly to be found in tubes 38—51. These tubes were therefore collected in a separate fraction and their characteristics were further studied.

Table 1 presents the characteristic features, quantities and P contents of myosins obtained from the two different muscles.

Table 1

Quantity and properties of myosin obtained from horse muscles

Source	Mincing, g	P content µmol/100 g wet weight	Dry matter content in muscle, %	Yield of ultracentrifuged myosin		Data of gel-filtrated myosins			
				mg	%	$\frac{E_{280}}{E_{260}}$	P content of myosin	P-lipid	RNA-P or nucleotide-P (ribose content)
							mol/mol		
m. long. dorsi	50	84	29.30	1095.0	2.18	1.79	66.0	6.7	0.15
m. rectus femoris	72	112	22.85	387.2	0.538	1.32	45.6	7.2	0.35

Table 2

Effect of Cu^{2+} ion on the P content of gel-filtrated myosin
(Final concentration 0.42 mol Cu^{2+})

Myosin	P content in myosin	
	before treatment	after treatment
	mol/mol	
m. long. dorsi	66.0	4.15*
m. biceps femoris	45.6	4.85*

* P content is corrected and calculated for lipid-free protein residue.

Table 3

Total, labile P and P-lipid content of mixed LC fraction. Data are given for an average molecular weight of 20,000 dalton

Source	Total P*	Labile P**	P-lipid	P content*** per dry weight
	mol/mol			
m. long. dorsi	10.4	7.95	0.32	1.11
m. biceps femoris	6.1	2.45	1.02	2.45

* Total P content referred to acetone-precipitated myosin.
** Released by Cu treatment.
*** Determined in Cu- and lipid-free protein residues.

The quantity of myosin does not reflect the myosin content of the individual muscles. Owing to the short extraction time, aimed at increasing the degree of purity, it does not even approach this quantity, but simply indicates the faster or slower rate at which the myosin molecules are released from the filamentous structure.

It is worth mentioning that the $E_{280}/_{260}$ ratio in the myosin of *m. long. dorsi* is much higher (1.78) than that in the myosin of *m. rectus femoris*. This can be explained by the fact that the specific structure of myosin depends on its origin, rather than by whether it has a very low or a somewhat kigher P content.

The higher P-lipid content of horse myosin, seen in Table 1, supports the theory outlined in the introduction. According to the data the myosin molecule of a trained muscle requires more P-lipid for its inner integration than the homologous muscle myosin of wild rabbit or hare.

Table 2 shows the effect of Cu^{2+} ions on the P content of gel-filtrated myosins. The samples were all treated with and stored in the same volume (0.84 mmol) of $CuCl_2$. The Cu ions initiate a slow precipitation of myosin, and after 24 hours the precipitate is so dense that it can be separated by centrifugation, and, as stated above, a large proportion of the P is found in the myosin supernatant as inorganic phosphate. The analytical results show that the P-lipid remains in the precipitate. The values in the table represent the P contents of Cu-treated samples after the deduction of the P-lipid; therefore, the amount of phosphate (4.15 and 4.85 mol) retained in the myosin presumably shows the value of "stable ester phosphate".

Tubes containing a mixture of the LC fractions were colected and mixed with 2 volumes of acetone. During overnight storage the protein precipitates and can be separated by centrifugation. Some of the protein was used for total P, P-lipid and labile P determinations, and the rest — after lipid removal and alkaline hydrolysis — for the separation of amino acid phosphates. In Table 3 some characteristic data of the LC fractions are summarized. The LC mixture still has a considerable P content; it is, therefore, worth attempting to obtain further information on the chemical nature of labile phosphates in these fractions.

In Fig. 6 the chromatogram of the myosin hydrolysate from *m. long. dorsi* is seen. There are many peaks giving a positive molybdate reaction in the figure, taking up almost the whole chromatogram. As a consequence of the repeated use and storage of the ampoules in concentrated KOH solution the 0.2—0.4 M $KHCO_3$ range of the chromatograms is free of silicate.

Due to the high salt content, even a combination of specific reactions and separation by paper chromatography does not provide sufficient information. Although the paper chromatographic Rf values of the individual amino acid phosphates in the system used for separation are known (P-Lys: 0.77—0.80, P-Arg: 0.70—0.73, Nπ-P-His: 0.54—0.60, Nτ-P-His: 0.40—0.43), $KHCO_3$ and KCl also display diffuse spots of violet colour (Rf 0.35 and 0.68, respectively) with the ninhydrin reagent because of the local alkalinity. In the case of high salt concentration the salt spots may occupy as much as 30—55% of the chromatogram. When Si polymers are present they are visible as white spots. The information obtained from samples with higher salt concentrations is, therefore, not sufficient for the evaluation of the amino acid phosphates. In response to a 24-hour treatment with iodine vapour some of the ninhydrin-positive spots may turn brown, or on rare occasions new spots may appear.

For these reasons the fractions were subjected to $HClO_4$ treatment, then applied to TLC sheets (Fixion Fertigfolien coated with Dowex 1×8) and the chromatogram was developed. As a response to the ninhydrin reagent two groups of basic and acidic amino acids

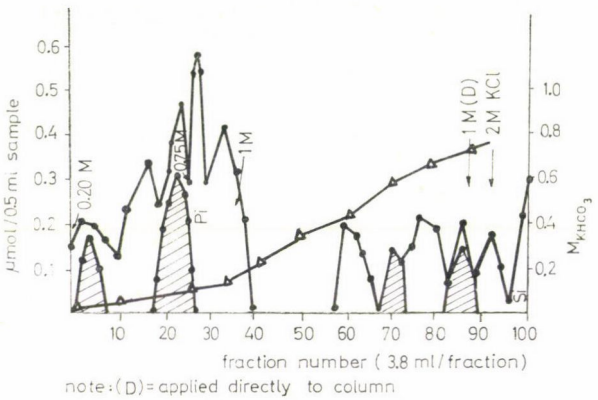

Fig. 6. Chromatographic separation of alkali-stable amino acid phosphates from the hydrolysate of gel-filtrated and lipid-free back muscle myosin (12 mg dry weight) on a Dowex I X-8 column (0.9×8 cm). The hydrolysate was diluted to a concentration of 0.01 mol/l KOH and percolated on the column. The elution was performed with the linear gradient chromatographic technique using a mixing vessel with a capacity of 165 ml and an electromagnetic stirrer. The concentration of $KHCO_3$ in the reservoir was continually increased by applying 0.2, 0.75 and 1.0 M $KHCO_3$ solutions (the changes are indicated by arrows). 1 M $KHCO_3$ was applied directly without mixing, and was followed by 2 M KCl for the regeneration of the column. The ordinate marks the molybdate-positive material, gained from myosin and collected in the tubes, against the abcisse; this was checked using a standard curve prepared from KH_2PO_4

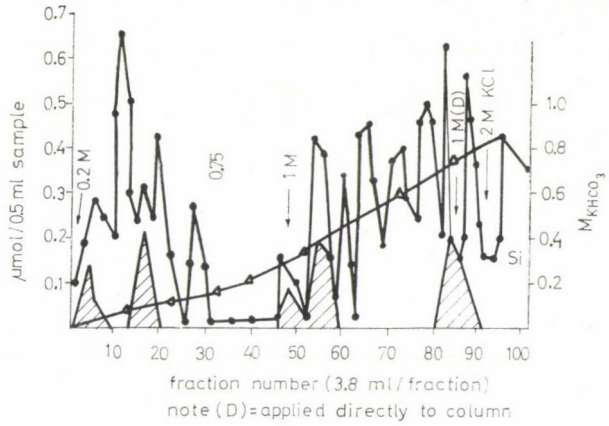

Fig. 7. Chromatography of alkaline hydrolysate of gel-filtrated and lipid-free myosin (30 mg dry weight) originating from *m. rectus femoris* of horse. Other legends as described in Fig. 6

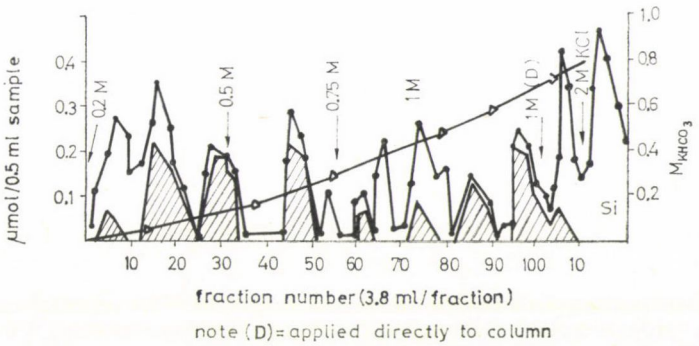

Fig. 8. Chromatography of hydrolysates of LC-mixture originating from *m. rectus femoris* myosin. Other legends as described in Fig. 6

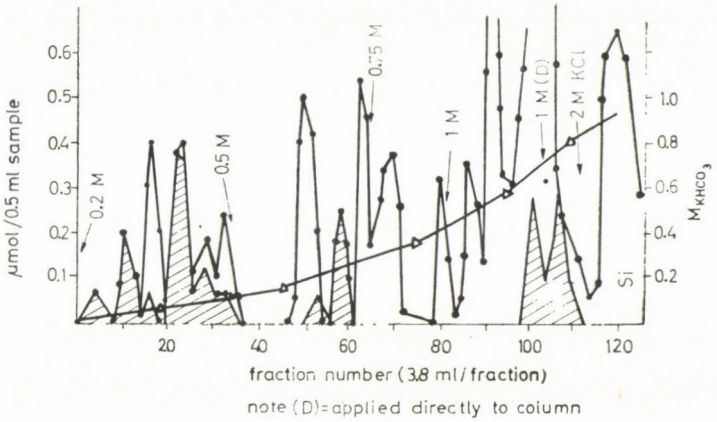

Fig. 9. Chromatography of ultracentrifuged but lipid-free myosin hydrolysate prepared from *m. rectus femoris*. Other legends as described in Fig. 6

were seen on the slides. Above 0.5 Rf spots of acidic amino acids, and below 0.30 Rf those of basic amino acids were found. Fractions which showed no basic amino acid spots were no longer taken into consideration. The blue colour of the molybdate reaction in these fractions originated from the Si content.

The ninhydrin positive spots on the chromatogram were identified on the basis of their Rf values. Finally, they too were exposed to iodine vapour for 24 hors and re-examined. In the case of basic amino acids, spots sometimes appear only under the influence of iodine vapour.

Fractions containing basic amino acids were used to determine the amino acid concentration and are shown in the chromatograms on this basis. With this method the localized P content in tubes repeated the P determination in presence of $HClO_4$, obtained the B-containing peaks on 1, 3, 4, 5, 6, 7, 8 and 9 (shaded areas).

In Fig. 7 the chromatogram of the myosin hydrolysate of *m. rectus femoris* is seen; it contains more basic amino acid than the myosin hydrolysate of *m. long. dorsi.*

Fig. 8 shows the hydrolysate of the LC fraction in *m. long. dorsi* myosin. In the chromatogram the number of basic amino acids is larger than that in gel-filtrated and lipid-free myosin hydrolysates.

For comparison the hydrolysate of non-gel-filtrated but lipid-free *m. rectus femoris* myosin was examined; the chromatogram is shown in Fig. 9.

Without gel-filtration the number of basic amino acids was higher, proving that some of them originated from the LC fraction. The comparison made it obvious that the LC fractions should be separated from one another and from the associated proteins by chromatography, in order to obtain the chromatograms of the individual LC chains (A_1, DTNB and A_2). This work is now in progress. In the mixed LC fraction N^{τ}-P-His was found at a much lower concentration than the other tautomer. At the same time, non-gel-filtrated myosin contained equal quantities of the two tautomers. After the release of P by acidic hydrolysis the P-His tautomer ratios disappeared, and in the hydrolysate two free His conformers were present, the ratios of which depended on the pH, though the chromatographic Rfs on the TLC sheets were identical.

Table 4 shows the phosphorylation of ultracentrifuged myosins. It is a question of theoretical importance whether the preparation of myosin from trained horse muscle can be phosphorylated and how the extent of phosphorylation compares with the phosphorylation of the control homologous muscle myosins. The results show that the answer is far from simple, and must be broken down into details to be understood.

1. The normal phosphorylation medium does not induce phosphate incorporation; moreover, the P content leads to reduced incorporation. It appears that the hydrolytic function of the myosin (ATP-ase activity) is enhanced, and that not only the hydrolysis of ATP increases, but also a large part of the bonded content is released and inorganic phosphate is produced. It is not known as yet whether NaCl or some other factor is responsible for the phosphorylation not taking place.

2. Hormones, alkaline pH and certain chemicals prevent the release of inorganic phosphate. When studying the effects of hormones they were incubated with the myosin before phosphorylation so as to achieve the maximum saturation of all molecules. Myosin prepared from *m. long. dorsi* when saturated with hormones (LVP, PGF_{2a}, Serotonin, NA and vitamin E) promotes the retention of the P content or the phosphorylation of the myosin. There seems to be every justification for referring to this as phosphorylation, because the P content shows an intensive increase in the presence of cGMP and a moderate increase when cAMP is present. Bradykinin has the opposite effect, causing a sharp reduction in the P content.

3. The P content of myosin from *m. rectus femoris* is decreased rather than increased by hormones and chemicals. The highest P content was found in the ultracentrifuged myosin preparation, after which every procedure and treatment reduced the P content.

Table 4

Phosphorylation of ultracentrifuged myosin prepared from m. long. dorsi (A) and m. biceps femoris (B). For phosphorylation 3.05 mg (6.3 nmol) myosin was used for A and 3.6 mg (7.6 nmol) myosin for B (P content is calculated for 478,000 g protein)

Sample	Modifiers or chemicals+ (μg or mg/total reaction mixture)	A	B
		mol P/mol	
Ultracentrifuged myosin (control)		44.35	48.5
Gel-filtrated myosin		66.0	45.6
Omitted ATP		21.7	25.0
Normal phosph. mixt.		6.45++	12.5++
Normal phosph. mixt. +	LVP (850 μg)	97.0	19.2
Normal phosph. mixt. +	$PGF_{2\alpha}$ (250 μg)	165.0	5.2
Normal phosph. mixt. +	Serotonin (800 μg)	300.0	32.5
Normal phosph. mixt. +	Bradykinin (100 μg)	14.4	28.5
Normal phosph. mixt. +	NA (50 μg)	232.0	11.8
Normal phosph. mixt. +	Vitamin E+++ (7.1 μmol)	71.5	13.2
Normal phosph. mixt. +	cGMP (1 μmol)	354.0	28.5
Normal phosph. mixt. +	cAMP (1.57 μmol)	135.0	35.5
Normal phosph. mixt. +	$NaHCO_3/Na_2CO_3$ (75 mmol, pH 9.5)	338.0	180.0
Normal phosph. mixt. +	Butane-2,3-dion (100 mmol)	11.3	12.0
Normal phosph. mixt. +	Phenylglyoxal (100 mmol)	13	15
Normal phosph. mixt. +	TNBS (20 mmol)	15.2	9.2
Normal phosph. mixt. +	Diethyl pyrocarbonate (20 mmol)	35.0	25.4
Normal phosph. mixt. +	NH_2OH (25 mmol)	18.5	13.2
Normal phosph. mixt. +	DTNB (2 mmol)	33.0	21.0
Normal phosph. mixt. +	EGTA (2 mmol)	35.0	32.2
Normal phosph. mixt. +	EDTA (2 mmol)	10.0	8.0
Normal phosph. mixt. +	Cu^{2+} (0.42 mmol)	10.6	4.15
Normal phosph. mixt. +	H^+ (2×10^{-9} M, pH 4.71)	39.0	27.5*

+ Modifiers or chemicals were added to myosin before phosphorylation in buffer.
++ The myosin A and B in the NaCl-containing medium show high ATP-ase activity only.
+++ 25 mM Tris-HCl buffer (pH 7.4) was saturated at 7.1 μM concentration of vitamin E.
* A large quantity of inorganic P remained bound by myosin and could not be washed out of the rough aggregate.

The difference between the two muscle myosins is already obvious after comparing the first few data in the table. The P content of myosin *from m. rectus* femoris decreases moderately in the course of gel-filtration, while that of *m. long. dorsi* myosin increases with the degree of purification. Any further treatment or the application of chemicals reduces the P content of *m. rectus femoris* myosin, with the exception of $NaHCO_3/Na_2CO_3$ buffer, which causes an increase in P content in both myosins.

Of the chemicals, the specific Arg, Lys and His reagents cause a decrease in the P contents of both myosin, suggesting the participation of basic amino acids in the process of

phosphorylation. H^+, Cu^{2+}, Zn^{2+}, Co^{3+}, TNBS, diethyl-pyrocarbonate, hydroxylamine, butane-2,3-dion and phenylglyoxal, mentioned in the Material and Methods section of this paper, reduce the P content of the myosin even without phosphorylation.

It should be noted that the phosphorylation experiments were performed with ultracentrifuged myosin and not with gel-filtrated myosin, as some of the LC fractions dissociate from the high P-content myosins, owing to their loose bonds, and can be collected as a separate peak in the course of gel-filtration.

The results show that definite and satisfactory answers have been obtained to the questions raised in the introduction. It can thus be established that the P content of myosin prepared from trained muscles (66 M P) is the highest of all, exceeding even the P content of NaCl-extracted hare muscle myosin (22—32.8 M P). This supplies evidence of an increase in physical work being proportionate to the increase in the molar P content, and even in the P-lipid content. This result is confirmed by the fact that the total phosphate (45.6 M P) and P-lipid ($\simeq$8 M) content of myosin prepared from a dynamic muscle of the horse *(m. rectus femoris)* also increased. This provides further justification for the hypothesis that P-lipid is an integral part of the myosin molecule, related not only with maintaining the structure of the molecule, but also with the physical activity and strength of the muscle.

The higher dry matter content and total phosphate content of the static muscle *(m. long. dorsi)* is noteworthy compared to the lower dry matter content and P content of the dynamic muscle *(m. rectus femoris)*. This fact may be related with the more constant, better balanced load and the intensive work of *m. long. dorsi* as a static muscle.

Ultracentrifuged myosins were used in most of the investigations on phosphate incorporation, since they showed higher autophosphorylating capacity than gel-filtrated myosins. Table 1 was compiled immediately after ultracentrifugation from the data of gel-filtration tests.

A detailed analysis of the P content revealed that most of the P content of trained horse muscles was labile phosphorus released under the influence of Cu^{2+} (Table 2). This was confirmed by the chromatographic separation of lipid-free myosin hydrolysates from both muscles (Figs 6, 7), and also by paper chromatography and TLC tests. In the paper-chromatograms mostly P-Arg, P-His were present, while in the lower third of the TLC sheets Arg, Lys and His were found. In addition to these, further basic amino acid phosphates and their derivatives are found in the myosin hydrolysate of *m. rectus femoris*.

In the chromatogram of the LC fraction even more basic amino acid phosphates and their hydrolytic products were observed.

Figure 6 shows the chromatographic separation of hydrolysates without lipid removal and the increased number of fractions containing phosphorus, thus emphasizing again the importance of lipid removal before hydrolysis. Hydrolysis products of P-lipids increase the number of fractions containing phosphorus and make their identification difficult. Detailed data on the quantitative distribution of phosphorus in horse muscles cannot be supplied until after the present and subsequent examinations have been completed, but it can definitely be stated that the phosphorylated derivatives of Arg, His and Lys were present in both muscle myosins. Recently other authors (MORNET *et al.* 1979) have also suggested the presence of Arg in the active centre of myosin and its participation in binding nucleotide-type substrates, while CHANTLER (1980) presents a theory involving the active participation of Lys, His and Tyr.

The present investigations have demonstrated from a different point of view that it really is a case of two distinct types of myosin, because in comparison to rabbit muscle myosin it is only the myosin of the homologous *m. long. dorsi* that is phosphorylated under the given conditions. It, therefore, appears reasonable to maintain the term "preparative myosin" in the case of both muscles, since under the influence of the purification procedure the P content gradually decreases, though at different rates; furthermore, in the control

incubation mixture (without ATP) the washing solutions cause the removal of still further co-valently bound phosphates.

The hormones and chemicals used in the phosphorylation experiments demonstrate the different behaviours of dynamic and static muscle myosins, as the *m. rectus femoris* myosin shows no P incorporation at all (except above pH 9.3) in contrast to the myosin of *m. long. dorsi*. The relevant data in the table cannot be considered to be of absolute value, but they clearly show the need for further experiments.

Finally, the available data demonstrate that myosin is one of the most important proteins as regards muscular function, because the phosphorylation ability of the His, Arg and Lys groups it contains, and the fact that phosphate saturation can be influenced in the whole myosin molecule, open up new vistas in research on muscular function.

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COMPARISON OF FODDER GRAINS (BARLEY, OAT AND SORGHUM VARIETIES) FOR NUTRITIVE VALUE ON THE BASIS OF LABORATORY ANALYSES AND FEEDING TESTS

I. LABORATORY ANALYSES

The grain fodder requirements of livestock farming are covered primarily by fodder grains. According to the evidence of exact and detailed statistical data, for the purpose of "quality protein production" intensive livestock farms in Hungary mostly use maize and fodder wheat, the protein contents of which hardly reach 10% over the average of many years. In other words, an annual 1.3—1.5 million tons more grain fodder is fed than would be required for an up-to-date, adequate protein supply (GONDA 1979).

Approximately three-quarters of the total protein demand of Hungary is covered from domestic production. The remaining 25% is mostly supplied from capitalistic imports; and if we consider that the existing fodder factories and mixing plants have limited capacities (not even enough to satisfy the current demand) it is easy to see that the growing area of plant species and varieties with higher protein and essential amino acid contents should definitely be increased.

It is common knowledge that the biological value of boneless meats is about 20% lower than that of egg-white (94%), while soy meal has a biological value of 73% and wheat flour of 52% (BÁLINT 1979). The biological values of all fodder grains — including barley, oats and sorghum — come between these two limits; the oat varieties come closest to the standard value of soy meal.

The possibilities of breeding for better nutritive value, involving not only an increase in the biological value of the protein, are extremely dependent on external factors (location, climate, fertilization and other cultural practices, etc.).

Thus, views differ as to whether ecological factors and the planned application of agrotechnical methods or the exploitation of the hereditary properties of fodder grain species and varieties are of primary importance. To make progress with the former method calls for a much better areal distribution than the present one, nutrient replacement based on extensive soil analyses and the cultural practices best suited to the potential demands of the variety.

On the other hand, increasing the adaptability of the varieties is a genetic problem; parallel to an improvement in yield reliability, this might perhaps be the most economical procedure (PALÁGYI—BENKE 1980).

Despite the expensive analyses involved, breeding fodder grains for quality must remain on the agenda. Over the last ten years SZIRTES (1971, 1972, 1974) has carried out pioneer work in this field, mainly with oats and barley. Not only has he called attention to the method of converting to the above-mentioned egg-white value, but has also urged the utilization of induced (EMS) mutant lines. Although he found that, owing to the extremely strong genotype × year interaction relative to the genotypic variance, progress through selection was very slow, modest results can nevertheless be achieved by further improving the analytical methods and by taking into consideration the possibility of yield components compensating each other.

Serial laboratory analyses cause considerable problems. When analysing components the standard deviation of outdoor (field replications) and indoor (laboratory) samples is always high, thus reducing the reliability of the experimental results.

This fact, and the need for a more complex knowledge of the nutritive value, made it imperative to carry out feeding (utilization) experiments which were hardly possible previously with these three species of cereals.

The feeding experiments were carried out at the Debrecen University of Agricultural Sciences, using rats and sheep as monogastric and polygastric model animals in 1977, and rats alone in 1978.

The investigations included

- laboratory analyses of components (crude nutrient composition and nutritive value, nutrient yield, gross energy and digestible energy content, amino acid composition),
- examination of the utilization (digestibility) of nutritive elements in rats,
- protein retention and production tests on rats,
- examination of nutrient utilization in sheep (in 1977 only),
- protein retention tests on sheep (in 1977 only).

The present paper only contains the results of the comparative laboratory examinations of the components; the feeding tests will be described in the following paper.

In the experiments grain fodder samples of the following varieties and variety candidates bred at the Cereal Research Institute were used (B = barley, O = oats, S = sorghum):

1977

B-1: GK-59 winter barley
B-2: GK-awnless winter barley
O-1: Szegedi (30) early* spring oats
O-2: Condor spring oats
S-1: Hybar 456 grain sorghum
S-2: Hybar 242 grain sorghum
S-3: GK-Tisza grain sorghum

1978

B-1: GK-59 winter barley
B-2: Mutant two-row winter barley
B-3: Horpácsi two-row winter barley
O-1: Szegedi (30) early* spring oats
O-2: Szegedi winter oats
O-3: GK-2 spring oats
O-4: GK-3 (awnless) spring oats
S-1: Tiszagyöngye grain sorghum
S-2: Szegedi 200 grain sorghum
S-3: Szegedi 613 grain sorghum
S-4: Napsugár grain sorghum
S-5: Remény grain sorghum

* The new selection Szegedi 30 spring oats was given preliminary state registration by the Council for Variety Qualification in 1978 under the name Szegedi korai spring oats, and will hereafter be referred to by this name.

Table 1

Composition of crude nutrients in air-dried samples of fodder grains; yield percentages per unit area gross (GE) and metabolizable energy (ME) values

1977

Code	Crude protein	Crude fat	Crude fibre	N-free extr. matter	Ash	Organic matter	Starch equivalent, g/kg	Digestible protein, %	GE	ME rat	ME sheep
	%								kJ/kg dry matter		
B-1 abs. %	11.30	2.22	3.09	65.89	2.50	82.50	716	8.69	15.74	13.23	13.48
yield %	114	77	84	109	127	107	115	108	106	113	109
B-2 abs. %	10.87	2.13	0.31	70.00	1.69	83.31	746	7.61	15.83	13.57	14.11
yield %	112	75	9	118	88	111	122	97	109	118	117
Average:	11.09	2.18	1.70	67.95	2.10	82.91	731	8.15	15.79	13.40	13.80
	113	76	47	114	108	109	119	103	108	116	113
O-1 abs. %	12.41	4.53	8.95	56.05	3.06	81.94	569	10.78	16.33	11.14	11.89
yield %	102	128	199	76	127	87	74	109	90	78	79
O-2 abs. %	10.76	3.74	9.22	56.84	4.44	80.56	515	8.87	15.83	10.01	11.35
output %	77	91	178	66	159	74	58	78	83	69	72
Average:	11.59	4.14	9.09	56.45	3.75	81.25	542	9.83	16.08	10.58	11.62
	90	110	189	71	143	81	66	94	83	69	72
S-1 abs. %	10.99	3.20	1.42	67.82	1.57	83.43	712	7.95	16.12	13.61	13.31
yield %	116	116	40	117	83	113	119	103	113	121	113
S-2 abs. %	11.39	3.52	2.63	66.27	1.19	83.81	784	9.61	16.29	14.57	14.78
yield %	102	108	63	97	54	96	111	105	97	110	106
S-3 abs. %	7.45	2.92	4.52	68.93	1.18	83.82	—	—	15.99	—	13.23
yield %	78	105	127	118	62	113	—	—	111	—	111
Average:	9.94	3.21	2.86	67.67	1.31	83.69	748	8.78	16.13	14.09	13.77
	99	110	77	111	66	107	115	104	107	116	110
Grand average	10.74	3.18	4.31	64.54	2.23	82.77	674	8.92	16.02	12.69	13.16
	100	100	100	100	100	100	100	100	100	100	100

Note:

The yield percentages for the grand average (100%) represent the average of all seven varieties examined. The yield percentage of each variety is related to these. GE = gross energy, ME_{rat} = metabolizable energy for rat, ME_{sheep} = metabolizable energy for sheep. Where the digestibility of crude fibre could not be measured, this nutrient is obviously not included in the ME values.

(This note also applies to Tables 2 and 3.)

Table 2

Composition of crude nutrients in air-dried samples of fodder grains; yield percentage per unit area, gross (GE) and metabolizable energy (ME) values

1978

Code		Crude protein	Crude fat	Crude fibre	N-free extr. matter	Ash	Organic matter	Starch equivalent, g/kg	Digestible protein, %	GE	ME_{rat}
		%								kJ/kg dry matter	
B-1	abs. %	9.30	1.90	5.20	66.20	2.40	82.60	676	6.65	15.62	12.31
	yield %	96	57	97	106	131	102	95	86	99	94
B-2	abs. %	8.70	2.10	4.10	67.80	2.30	82.70	710	6.26	15.66	12.90
	yield %	93	64	79	112	130	105	103	84	103	101
B-3	abs. %	11.30	1.90	3.60	66.00	2.20	82.80	707	8.50	15.74	12.94
	yield %	111	54	64	101	115	98	95	104	96	94
Average		9.77	1.97	4.30	66.67	2.30	82.70	698	7.17	15.67	12.72
		100	58	80	106	125	102	98	91	99	96
O-1	abs. %	12.60	5.00	13.70	50.90	2.80	82.20	660	11.19	16.54	12.90
	yield %	106	121	208	66	125	83	76	117	86	80
O-2	abs. %	12.10	5.50	13.90	51.00	2.50	82.50	714	10.78	16.71	13.86
	yield %	108	141	224	70	118	88	87	120	92	91
O-3	abs. %	13.90	4.50	13.40	50.30	2.90	82.10	650	12.89	16.50	12.77
	yield %	112	104	196	63	124	79	72	130	82	76
O-4	abs. %	15.70	5.20	7.60	53.80	2.70	82.30	709	14.04	16.66	13.40
	yield %	139	132	121	74	126	87	86	155	91	87
Average		13.58	5.05	12.15	51.50	2.73	82.28	683	12.26	16.60	13.23
		116	125	187	68	123	84	80	131	88	84
S-1	abs. %	7.71	3.20	2.11	70.80	1.18	83.82	755	5.21	16.04	13.78
	yield %	83	99	41	118	67	108	111	70	107	109
S-2	abs. %	7.56	3.66	2.41	70.38	0.99	84.01	759	5.10	16.16	13.86
	yield %	82	115	48	119	57	110	113	69	109	111
S-3	abs. %	7.86	2.70	2.07	71.30	1.07	83.93	811	6.97	15.95	14.86
	yield %	88	87	42	123	64	112	124	97	110	122
S-4	abs. %	6.33	3.25	1.77	72.64	1.01	83.99	770	4.41	15.99	14.03
	yield %	74	110	38	132	63	118	124	65	116	121
S-5	abs. %	9.78	3.75	2.12	68.00	1.35	83.65	744	7.20	16.20	13.73
	yield %	109	120	43	117	80	111	113	100	111	112
Average		7.85	3.31	2.10	70.62	1.12	83.88	768	5.78	16.07	14.05
		87	106	42	122	66	112	117	80	111	115
Grand average		10.24	3.56	6.00	63.26	1.95	83.05	722	8.29	16.15	13.45
		100	100	100	100	100	100	100	100	100	100

Table 3

Composition of nutrients in air-dried samples of fodder grains; yield percentages

1977—

Code		Crude protein	Crude fat	Crude fibre	N-free extr. matter	Ash	Organic matter
		%					
Barley:	abs.	10.29	2.05	3.26	67.18	2.22	82.78
	yield	104	66	66	110	113	105
Oats:	abs.	12.91	4.75	11.13	53.12	3.07	81.91
	yield	106	124	184	70	124	84
Sorghum:	abs.	8.63	3.28	2.38	69.52	1.19	83.81
	yield	90	110	50	119	63	111
Average (of all varieties)		10.61	3.36	5.59	63.27	2.16	82.83
		100	100	100	100	100	100

Note: for the energy values "r" = rat; "sh" = sheep.

As seen above, only the winter barley GK-59 and the early spring oat Szegedi (30) were examined in both years, but the aim was to obtain informative data on as many varieties as possible within the three grain species. This, and the high cost of the experiments, were the reasons why sheep were not included in the feeding tests in 1978.

The samples were perfectly clean, expertly stored grains from fodder plants grown in the previous year on trial plots at more or less identical locations on soil with medium nutrient status.

[The sorghum sample S-3 (GK-Tisza) arrived late in 1977, so the analytical results are incomplete.]

Since only GK-59 winter fodder barley (B-1) and Szegedi korai spring oats (O-1) were included in the experiment in both years, the results are given for the two years separately. The varieties are compared to one another, while the species are evaluated by comparing the average of the varieties.

The laboratory analyses of the components were performed according to the descriptions laid down in the standard (MSZ No. 6830). The crude nutrient composition of the samples is expressed as a percentage of the air-dried material (Tables 1, 2 and 3). (The results of amino acid analyses are found in Tables 4 and 5.) Besides the absolute quantities of crude nutrients contained in the air-dried matter, the yields per unit area are given as percentages.

The Hungarian fodder standard is to be found in HEROLD's (1977) text-book (MSZ 6830-66), which also contains the formulae for gross energy (GE) and digestible (metabolizable) energy (ME) calculations elaborated by Nehring-Schiemann et al., which lend themselves for comparison with the results reported by EGGUM (1977) and BHATTY *et al.* (1975).

Barley varieties

1977

The variety GK-59 is somewhat richer in crude protein than the awnless barley, as shown, for instance, by the yield percentages. GK awnless barley, on the other hand, contains ten times less crude fibre, which is replaced by a larger quantity of readily digestible carbohydrate (N-free extractable matter), and also much less ash. The awnless barley, while having

per unit area, gross (GE) and metabolizable energy (ME) values

1978

Starch equivalent, g/kg	Digestible protein, %	GE/77	ME_r/77	ME_{sh}/77	GE/78	ME_r/78
		kJ/kg dry matter				
711	7.56	15.79	13.40	13.80	15.67	12.72
106	95	108	116	113	99	96
636	11.45	16.08	10.58	11.62	16.60	13.23
76	118	83	69	72	88	84
762	6.65	16.13	14.09	13.77	16.07	14.05
117	87	107	116	110	111	115
703	8.55	16.02	12.69	13.16	16.15	13.45
100	100	100	100	100	100	100

a higher organic matter content and starch equivalent, is considerably poorer in digestible protein. Its gross energy and metabolizable energy contents are substantially better, however. The yield values of metabolizable energy in the latter variety exceed those of the variety GK-59 by 5—9%. This single example is enough to show that the composition value does not depend solely on the protein content. By producing awnless varieties it is possible to eliminate certain yield components (glume, awn) which are of no use from the point of view of feed conversion (PALÁGYI—BENKE 1976). It is worth noting here that the mass increase was better in rats fed with awnless barley.

There is no substantial difference between the two barley varieties with respect to the 13 essential amino acids examined. Both varieties are very poor in methionine, poor in arginine, lysine, threonine, glycine and cistine, and rich in valine and leucine.

1978

As regards crude protein the variety Horpácsi two-row was found to be the richest, though even this variety contained only just enough to meet the requirements of the Hungarian fodder standard. The other two varieties are much poorer in crude protein; the same applies to their yield values. The crude fat contents of the varieties are much more uniform, though lower than the average (2.3%) given in the fodder table. In comparison to the grand average found in Table 2, the yield values of crude fat range between 54 and 64%. The Mutant two-row winter barley comes closest to the value in the table. This variety is the best with respect to organic matter yield, starch equivalent, and gross and metabolizable energy production, too. The strains of this selection would be worth examining further.

There is no substantial difference in the absolute quantity of N-free extractable matter between the three barley varieties: their values correspond to those in the fodder table. The ash content is lower than average in all three, but is still higher than in the other fodder grain species examined. The barley varieties are also considerably poorer in digestible protein than the accepted value.

The essential amino acids amounted to 46.32% of the average crude protein content in the three barley varieties examined, which is a fairly average value. The quantity of essen-

tial amino acids is more or less the same in the varieties GK-59 and Mutant two-row, and much lower in Horpácsi two-row barley.

All the barley varieties examined are particularly poor in methionine, cistine and glycine, and very rich in isoleucine, valine and phenylalanine. Their threonine, histidine and tryptophane contents are moderate.

Oats

1977

Szegedi korai is substantially richer in almost every nutritive element (crude and digestible protein, fat, starch equivalent, organic matter) and consequently in energy, too, than the other variety examined, particularly when the percentage yield values are compared. Even if nothing but the approx. 15% (25% in yield value) protein surplus and 21% fat surplus are considered, the variety Szegedi korai must be regarded as much more valuable than the variety Condor. For obvious reasons both these awned oat varieties contain a large quantity of fibre, that causes problems when feeding rats. (This is why the ME values for rats are so low, though they are much lower in the case of sheep, too, compared with the representatives of the other two species.)

Furthermore, the data unequivocally show that the essential amino acid contents of the two oat varieties are much higher than those of the other fodder grains examined. Compared to other varieties, Szegedi korai has a higher phenylalanine and lysine content, and Condor a higher methionine and tryptophane content, though they are still poorer in methionine than the desired minimum, and this deficiency is only partly compensated by the amount of cistine. Both oat varieties are relatively poor in threonine, but have a reasonably high content of other amino acids.

1978

Among the data in Table 2 the values for crude and digestible protein are the most surprising. Both the absolute quantities and the yield percentages are outstanding compared to the grand average for the experiment. The same can be said of the crude fat, and naturally, of the raw fibre content.

The awnless spring oat GK-3 proved particularly rich in crude protein, though GK-2 was also found to have a high protein content.

The data on crude fat and total organic matter show less variation; Szegedi winter oats and the awnless variety GK-3 proved the best; the same applies to the yield values.

The raw fibre content in GK-3 is hardly more than half of that in the other three oats. The Szegedi korai spring oat variety, though it still has a fairly high crude fibre content, has the lowest glume percentage in the Hungarian variety assortment, according to experimental data collected by the authors over several years and by measurements made at the National Institute for Agricultural Variety Testing (PALÁGYI 1979); this partly explains the lower fibre content.

The starch equivalent is the highest in Szegedi winter oats and GK-3. This is understandable to a certain extent, since winter oats have more time to develop than spring oats (SOMORJAI—NAGY 1968), while GK-3, being awnless, accumulates a minimum amount of ballast material.

The digestible protein contents of the awnless variety GK-3, and even of GK-2, are outstandingly high compared to the other two varieties, as reflected by the yield percentages, though even the latter varieties contain more digestible protein than the average set down in the Hungarian standard (7.1%).

Table 4

Essential amino acid composition of protein in the samples examined (g/100 g crude protein)

1977

Amino acid	Desirable essential amino acid content	Actual amino acid content in the samples									
		B-1	B-2	Average	O-1	O-2	Average	S-1	S-2	S-3	Average
Asparagic acid	...	5.41	4.64	5.03	8.23	6.01	7.12	4.80	6.16	7.35	6.10
Threonine	3—4	2.78	2.19	2.49	2.31	2.64	2.48	2.57	1.83	3.23	2.54
Serine	...	3.39	2.71	3.05	4.15	3.58	3.87	2.52	2.46	2.98	2.65
Glutamic acid	...	32.77	36.33	34.55	20.69	20.24	20.47	25.77	24.66	22.06	24.16
Proline	...	7.48	7.93	7.71	6.92	4.42	5.67	5.74	8.50	5.98	6.74
Glycine	5—6	4.64	3.52	4.08	5.23	6.96	6.10	3.48	2.50	4.10	3.36
Alanine	...	4.53	3.65	4.09	7.54	6.75	7.15	10.00	9.00	9.44	9.48
Cistine	1—3	1.19	0.93	1.06	0.95	1.05	1.00	0.56	0.43	0.65	0.55
Valine	3—5	6.16	7.09	6.63	5.23	8.01	6.62	5.25	4.16	3.45	4.29
Methionine	2—3	0.93	0.89	0.91	0.96	1.48	1.22	0.94	0.66	1.01	0.87
Isoleucine	3—4	3.33	3.65	3.49	4.23	3.26	3.75	6.46	4.00	5.98	5.48
Leucine	4—7	6.27	7.67	6.97	7.69	8.01	7.85	14.91	15.33	17.23	15.82
Tyrosine	2—4	2.51	2.03	2.27	3.23	3.26	3.25	3.08	3.66	2.30	3.01
Phenylalanine	2—5	4.35	4.22	4.29	5.23	4.74	4.99	4.32	4.74	3.68	4.25
Lysine	4—7	2.89	2.61	2.75	4.46	4.00	4.23	1.15	1.66	2.53	1.78
Histidine	2—3	2.07	1.67	1.87	2.46	2.32	2.39	1.50	2.16	1.84	1.83
Arginine	5—7	4.58	4.48	4.53	6.00	6.64	6.32	2.44	2.50	3.68	2.87
Tryptophane	1—2	1.11	1.39	1.25	1.16	1.34	1.25	0.89	0.91	1.24	1.01
Total essential amino acids	37—60	42.81	42.34		49.14	53.71		47.55	44.54	50.92	
Species average				42.58			51.43				47.67

Note:

The essential amino acid requirement is to be understood chiefly for pigs and poultry. Amino acids marked with dots are generally not essential for farm animals, or the deficiencies can be made up by adding essential amino acids.

Table 5

Essential amino acid composition of protein in 1978

Amino acid	Desirable essential amino acid content	Actual amino acid content					
		B-1	B-2	B-3	Average	O-1	O-2
Asparagic acid	...	7.94	6.35	6.00	6.76	8.53	8.48
Threonine	3—4	3.73	3.95	3.75	3.81	4.37	3.39
Serine	...	4.66	4.73	4.50	4.63	4.92	5.10
Glutamic acid	...	23.84	24.34	25.90	24.69	24.31	21.72
Proline	...	7.47	10.39	12.22	10.02	5.78	5.27
Glycine	5—6	4.66	3.95	3.75	4.12	5.25	4.70
Alanine	...	4.43	3.70	3.48	3.87	4.02	4.70
Cistine	1—3	0.47	0.26	0.75	0.49	0.53	1.50
Valine	3—5	5.60	6.33	4.72	5.55	5.47	5.65
Methionine	2—3	0.94	0.80	1.00	0.91	0.53	0.56
Isoleucine	3—4	7.70	7.66	3.48	6.28	3.81	3.86
Leucine	4—7	4.21	3.72	6.22	4.72	6.48	7.15
Tyrosine	2—4	2.58	3.17	2.73	2.83	2.59	2.84
Phenylalanine	2—5	5.13	6.07	5.25	5.48	5.76	5.65
Lysine	4—7	3.96	2.39	3.48	3.28	4.20	4.51
Histidine	2—3	2.32	2.91	2.25	2.49	2.44	2.84
Arginine	5—7	5.83	5.81	3.97	5.20	6.55	7.69
Tryptophane	1—2	1.30	1.16	1.00	1.15	0.96	0.96
Total essential amino acids	37—60	48.43	48.18	42.35		48.93	51.30
Species average					46.32		

Note:

The essential amino acid requirement is to be anderstood chiefly for pigs and poultry. Amino acids marked with dots are generally not essential for farm animals, or the deficiencies can be made up by adding essential amino acids.

Particularly worthy of note are the high gross energy content of oats and the metabolizable energy content calculated for rats. In Table 3 the species can be well compared in the different years: as regards biological value, the sorghum varieties are placed first in 1977 and the oats in 1978, far exceeding the barley varieties. In this two-year list of results the better quality composition of oats in 1978 is clearly seen.

An average of 50.15% of the crude protein content in the four oat varieties examined came from essential amino acids. This is a fairly good result, giving evidence of a biological value higher than that in the sorghum and barley varieties examined. The methionine content is much lower than desirable in all four oat varieties. As for lysine, only GK-3 showed a very slight deficiency.The somewhat low glycine content of Szegedi winter oats and GK-3, and the methionine deficiency characteristic of the species are partly compensated by the relatively high cistine level. This is particularly so for the awnless experimental GK-3. The threefold cistine content of Szegedi winter oats, which also had the highest arginine and lysine contents (compared to all the varieties examined) should be mentioned as a positive feature.

A sufficient quantity of the other essential amino acids is contained in all the oat varieties; they are very rich in valine, leucine, phenylalanine and arginine and moderately so in isoleucine, tyrosine and histidine.

the samples examined (g/100 g crude protein)

in the samples

O-3	O-4	Average	S-1	S-2	S-3	S-4	S-5	Average
9.46	9.05	8.88	6.86	6.30	5.54	6.77	5.74	6.24
3.45	3.81	3.76	3.04	2.38	2.05	1.85	1.71	2.21
4.96	5.24	5.06	3.56	3.45	3.80	3.38	2.87	3.41
23.59	21.77	22.85	22.08	22.28	21.30	21.54	22.97	22.03
4.96	5.12	5.28	9.40	8.29	14.59	9.85	12.29	10.88
5.25	4.85	5.01	4.95	3.69	3.51	3.38	4.01	3.91
4.65	4.72	4.52	9.65	9.97	9.05	9.23	9.18	9.42
0.46	2.11	1.15	0.67	0.71	0.65	0.69	0.64	0.67
5.71	5.38	5.55	5.20	5.23	3.80	4.61	3.77	4.52
0.60	0.53	0.56	1.02	1.01	0.96	1.23	0.90	1.02
4.96	3.93	4.14	4.06	4.64	3.80	4.61	3.44	4.11
6.47	7.35	6.86	13.07	13.16	12.66	12.61	14.15	13.13
2.55	3.28	2.82	3.30	2.34	2.62	2.46	2.29	2.60
5.56	5.38	5.59	4.19	5.34	3.50	4.31	4.01	4.27
4.35	3.93	4.25	2.03	1.54	2.63	2.77	2.29	2.25
2.40	2.62	2.58	2.29	2.61	2.33	2.46	2.29	2.40
6.61	6.92	6.94	2.92	3.10	3.51	3.38	3.16	3.21
0.93	0.96	0.95	1.13	1.17	1.11	1.21	1.09	1.14
49.30	51.05		47.87	46.92	43.13	45.57	43.75	
		50.15						45.45

Sorghum

1977

The percentage of organic matter in the dry matter contents of sorghum varieties is nearly the same, since there is very little variation in the ash content. The much lower organic matter yield of Hybar 242 is explained by the fact that its vegetation period is the shortest of all the sorghum varieties examined, as a consequence, its yield is low.

GK Tisza is richer in easily digestible carbohydrates (N-free extractable matter) and contains 1.5—3 times more fibre than the other two varieties, while as regards fat and above all protein content it is much inferior to them. On the basis of the absolute values of crude nutrients, Hybar 456 and Hybar 242 are of higher feeding value than GK Tisza. This is also true of their gross and metabolizable energy contents.

With regard to the essential amino acid content sorghum is placed between oats and barley. (This is obvious from the species averages in Table 4. The less favourable proportions of the individual amino acids, on the other hand, mean that sorghum is less well-balanced even compared to barley.) Hybar 456 contains by some 8% more essential amino acids than Hybar 242, though its protein content is slightly lower. All three sorghums are very poor in threonine, glycine, cistine, methionine, lysine and arginine, and poor in histidine and tryptophane, while they are rich in isoleucine and very rich in leucine. (The great excess of the latter amino acid prevents valine and isoleucine from exerting any effect.)

1978

The experimental variety Remény is the richest in crude and digestible proteins and crude fat, though the protein level of all the varieties is far below the value shown in the fodder table. The same is true of their crude fibre contents which, however, is a favourable character. Considering that the yield levels of the five sorghum varieties examined are nearly equal, the yields follow the trend of the absolute component values.

Remény contained the least N-free extractable matter and Napsugár the most, but all the varieties exceeded the standard. The same can be said of their crude fat content. The ash content was the highest in the experimental variety Remény, while no substantial difference in total organic matter content was found between the five sorghum samples.

As regards starch equivalent, the variety Szegedi 613 leads with a very high value (811 g/kg), though the starch equivalent yield is equalled by Napsugár due to its better yield average. It should be noted that the starch equivalent of all the sorghum varieties examined is 3—10% higher than the average value shown in the Hungarian fodder table.

It partly follows from the above that each variety must be of good biological value; there is hardly any difference between them in this respect. The energy yield per unit area (including the metabolizable energy content) is far above the grand average of the experiment (by 11 and 15% higher, respectively). The best value of metabolizable energy for rats was found in Szegedi 613.

The essential amino acids made up an average of 45.45% of the protein content in the five sorghum varieties examined. This can be regarded as a medium value. Tiszagyöngye had the best quality protein, being deficient only in the sulphur-containing amino acids, and in lysine and arginine. The experimental variety Remény is an excellent example of the antagonism between quantity and quality, since it has the poorest protein composition, being deficient for seven amino acids. The other varieties have a deficiency in 6 amino acids each.

*

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AN ANALYSIS OF EXTERNAL HINDQUARTER MEASUREMENTS IN HEIFERS

There are two basic points which must be considered when studying the formation of hindquarters in cattle. One is that this part of the body is, in general, rich in the musculature which provides high value cuts (LŐRINCZ—LENCSEPETI 1973). Another point is that several attempts have already been made to find relationships between the linear measurements of this region and calving difficulties (MENISSIER 1974, HOLLÓ *et al.* 1976, GERE—BARTOSIEWICZ 1979b, BARTOSIEWICZ—GERE 1983). Usually the majority of both these kinds of studies are chiefly concerned with beef breeds or their crosses. In meat purpose populations the proportion of high value cuts and intensive reproduction are among the key factors of productivity.

This recent study, however, is basically concerned with the comparison between a type of dairy heifers (Holstein Friesians from the Experimental Farm of the Hungarian Academy of Sciences) and heifers from the F_1 generation of a beef oriented cross (Limousine × Red Pied Hungarian crosses from the Mezőhék Táncsics Co-operative Farm and the Hajdúszoboszló State Farm). The first type was represented by 82 and the second by 94 individuals. Only healthy animals were studied. The comparison uses three rump measurements, body weight and age.

During previous research (BARTOSIEWICZ 1978) four main ontogeny stages were identified on the basis of age (independent variable) and live weight (dependent variable). The validity of these stages was checked by studying nine of the most commonly used body measurements (such as wither height, girth circumference, etc.). Growth intensities in the four phases proved to be different for the dairy and beef purpose breeds compared here, although the basic pattern of periodic growth appears to be the same. The three measurements of hindquarters involved in this study were hip width, rump width and rump length. These measurements correspond to a trapezoid formed by the tuber coxae and tuber ischiadicum on both sides of the pelvis. The involvement of live weight in these calculations is explained by its general influence on linear measurements (BUDAY 1943) and even on skeletal variation in different species.

Modern cattle breeding also makes more use of weight data (biological age for weaning, insemination, etc.) than of chronological age. Optimal slaughter ages and weights are variable as well.

The mean values, standard deviations and coefficients of variation of the variables used here are shown in Table 1. The coefficients of variation (cv) in this table suggest that the width measurements of the hindquarters display standard deviations (sd) relative to the sample means ($\bar{x}$). This variability is smaller in beef purpose heifers and tends to slightly decrease in both constitutional types during ontogeny. As such, the rump length of beef heifers belonging to the third and fourth age groups is less variable.

The single correlations shown in Tables 2a and 2b were found between the pairs of variables in the eight groups.

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Table 1

Mean values ($\bar{x}$), standard deviations (sd) and coefficients of variation (cv) of the variables in the eight groups studied

Group	1			2			3			4		
	$\bar{x}$	sd	cv	$\bar{x}$	sd	cv	$\bar{x}$	sd	cv	$\bar{x}$	sd	cv
Beef purpose heifers												
Age	51.05	31.87	62.43	182.47	30.57	16.75	305.52	44.02	14.41	667.61	264.82	39.66
Live weight	69.43	20.27	29.20	181.63	29.28	16.12	291.29	36.61	12.57	452.57	96.05	21.22
Hip width	20.54	3.19	15.54	30.37	2.75	9.06	38.71	3.50	9.03	47.62	9.97	10.45
Rump width	10.37	1.07	10.35	14.16	2.83	20.01	18.70	1.21	6.48	22.04	2.47	11.25
Rump length	24.78	3.53	14.23	34.47	2.38	6.93	43.29	2.99	6.90	48.38	4.07	8.41
Dairy purpose heifers												
Age	45.32	40.86	90.16	174.27	21.54	23.83	322.64	42.40	13.14	546.66	139.43	25.51
Live weight	56.00	29.86	53.32	160.04	24.35	15.22	298.41	74.88	24.82	409.20	70.64	17.26
Hip width	20.68	4.14	20.04	30.18	2.87	9.52	40.23	5.84	14.51	45.14	4.68	10.36
Rump width	10.91	1.34	12.30	14.73	2.31	15.71	20.45	3.08	15.06	22.45	2.98	13.29
Rump length	26.23	4.32	16.47	32.73	2.81	8.60	40.91	5.48	13.39	45.71	30.82	8.36

(Age in days, live weight in kilograms, linear measurements in centimetres)

Table 2a

Changes of the single correlations between the variables during ontogeny

	Beef purpose heifers							
	Live weight	Hip width	Rump width	Rump length	Live weight	Hip width	Rump width	Rump length
Group	1				2			
Age	*0.859*	0.526	*0.751*	*0.708*	*0.879*	0.255	*0.774*	*0.720*
Live weight		0.651	0.621	*0.752*		0.466	0.615	*0.738*
Hip width			0.128	0.610			0.057	0.529
Rump width				0.665				0.653
Group	3				4			
Age	*0.902*	*0.736*	0.327	0.598	*0.954*	*0.755*	0.196	0.519
Live weight		*0.822*	0.508	0.652		*0.808*	0.339	0.617
Hip width			0.641	*0.832*			0.435	*0.830*
Rump width				0.455				0.548

Table 2b

Changes of the single correlations between the variables during ontogeny

	Dairy purpose heifers							
	Live weight	Hip width	Rump width	Rump length	Live weight	Hip width	Rump width	Rump length
Group	1				2			
Age	*0.977*	*0.979*	0.333	*0.948*	*0.957*	0.598	0.659	0.595
Live weight		*0.975*	0.421	*0.901*		0.472	0.568	0.434
Hip width			0.396	*0.927*			*0.710*	0.530
Rump width				0.200				0.551
Group	3				4			
Age	0.560	0.641	0.275	0.588	*0.730*	0.578	0.585	0.663
Live weight		0.623	0.493	0.623		0.729	0.534	0.511
Hip width			*0.830*	*0.912*			*0.749*	*0.715*
Rump width				*0.758*				0.607

The significant coefficients which show high correlations appear in italics ($P \leq 0.05$, $r \geq 0.7$). From the table, it can be seen that with only one exception age and live weight are always highly correlated. Among the three linear measurements the rump length (which proved to be the least variable in the previous comparison) is well correlated with the age and weight in young calves, and with the hip width in older individuals. Correlations involv-

ing the rump width display the smallest values with the exception of beef-type calves (the first two age groups of beef purpose heifers), where rump width is highly correlated with the age of the animals. On the other hand, this measurement is closely connected to the hip width in dairy heifers. There are four values greater than 0.7 in each age group for beef purpose heifers. Dairy heifers, however, have the greatest number of coefficients showing such a high correlation in the first group.

Another way to describe the rump formation of cattle is by the use of traditional indices: these values show the proportion of hip width as a percentage of rump width; however, they omit rump length (HORN 1955). The interpretation of rump formation indices is much easier when made simultaneously with the evaluation of relative growth speeds (FÁBIÁN 1969). These latter values (b) are presented here (Table 3) to express the slopes of allometric lines, which reflect the changes in the measurements in question relative to the live weight. Detailed results of these calculations are found in a separate paper (BARTOSIEWICZ 1978). The allometric coefficients showing the most intensive growth are marked (by italics) in each column.

As shown by the coefficients of growth (b values of the linear equations describing the growth process at various ages), the early maturation of beef heifers causes more intensive growth in the hindquarters of young calves raised for meat purposes. On the other hand, dairy heifers bred for steady development and consistent milk production (physiological balance) do not show such sudden growth in the first age group, while the strong growth of rump measurements relative to live weight lasts longer. The growth tendencies for width measurements of the hndquartes are similar in both kinds of heifers.

In order to illustrate the effect of differential growth on the proportions of this region, rump formation indices were calculated and summarized (using the coefficients of growth from Table 3) in tabulated form (Table 4). This presentation makes it easier to interpret both sets of values by showing the causality in their relationships.

When comparing the indices in this table it can be seen that the hip width of beef cattle is relatively wider in all age groups, although this difference in average hip widths

Table 3

Coefficients of growth (b values) showing the intensity of linear growth in the various age groups

	1	2	3	4
		Beef purpose heifers		
Hip width	*0.46411*	0.24716	0.57351	0.41316
Rump width	0.23832	0.64214	0.25078	0.18453
Rump length	0.37446	0.28936	0.31599	0.25928
		Dairy purpose heifers		
Hip width	0.36717	0.34631	*0.81390*	0.46397
Rump width	0.10803	*0.67715*	0.33386	*0.47316*
Rump length	0.29290	0.13825	0.71615	0.40917

(The relative growth of the linear measurements was calculated as the function of live weight)

Table 4

Rump formation indices interpreted by the corresponding coefficients of growth (b)

Age group	Beef purpose heifers			Dairy purpose heifers		
	Rump formation index	b Hip width	b Rump width	Rump formation index	b Hip width	b Rump width
1	200.0	0.46411	0.23832	190.0	0.36717	0.10803
2	214.3	0.24716	*0.64214*	203.3	0.34631	*0.67715*
3	206.9	*0.57351*	0.25078	197.0	*0.81390*	0.33386
4	215.9	0.41316	0.18453	197.2	0.46397	0.47313

$$\text{Rump formation index} = \frac{100 \cdot \text{Hip width}}{\text{Rump width}}$$

becomes significant only between the last, more mature groups of dairy and beef heifers ($P \leq 0.05$). On the other hand, average rump widths are significantly greater in dairy heifers of the first, second and third age groups ($P \leq 0.01$, $P \leq 0.05$, $P \leq 0.05$) than the same measurements in beef heifers of similar age. Relatively narrow rump width is characteristic of the Limousine breed (VÁGI 1976) and graphic representations of these indices have also shown that beef heifers tend to have a more caudally narrowing rump formation, while the rump lengths of dairy heifers seem to form a smaller angle.

Three different conclusions can be drawn from these results. The intensities of growth are rather similar in both purpose heifers in terms of maximum growth speeds relative to the live weight. They occur in the same order during ontogeny in both breeds. In the second development stage the intensive growth of the rump width is probably the indicator of important changes in the whole skeletal system of the species. The same intensive growth could be observed in the case of shank circumference at this age (GERE—BARTOSIEWICZ 1979a). It is well known that ossification is a process which finishes relatively early as opposed to the formation of other tissues. This fact immediately explains why the hip width reaches the maximum of its growth speed only in the following, third stage of development. This measurement is more influenced by the growth of musculature and fatty tissues. Thus, hip width is more highly correlated with the live weight, and can even be used as part of a formula for estimating body mass (DOBICKI 1973). The most remarkable difference between the growth speeds of the two breeds is that while the formation of hip width is fairly dynamic and uneven in beef purpose heifers, this tendency is less characteristic of rump formation in the dairy breed. Differences in hindquarter proportions, on the other hand, do not have a significant correlation with muscle distribution or meat quality. Other width measurements, however, proved to be correlated with the results of fattening as well (BRELOH—LÜKE 1971). Here it is worthwhile mentioning that in dairy cows a long, relatively horizontal rump is assumed to favour the location of the udder for machine-milking. This, however, may be the interpretation of an as yet unproven functionality, for which no experimental evidence exists, although intensive growth of rump length occurs in the third age group of the dairy heifers under study.

Finally, the conclusions reached touch upon the problem of calving difficulties and perinatal mortality, which far exceed the framework of this study. Extensive discussion of the question is, therefore, not attempted here. However, it is important enough to bear a brief mention. Apart from the different growth tendencies and proportions of the width measurements in the two types (Table 4) one has to reckon with the correlation of hip width and live

weight in calves and with the fact that the calving period is generally burdened by numerous physiological and anatomical complications. Among domestic animals cows have the most poorly designed pelvic formation for giving birth. The difficulty is partly due to the unfortunate location of the spina ischiadica and the bottlegourd-like proportions of the inner formation. Fleckvieh type cows sometimes possess short, narrow birth canals, which may be the source of further complications. Unfortunately the great variability of these measurements does not allow for efficient selection against such traits (CHRENEK 1978). The inner and outer dimensions of the pelvic region are not highly correlated either, because the inner measurements show relatively greater longitudinal growth intensity (GERE—BARTOSIEWICZ 1979b).

It should not be forgotten, however, that any given calving problem is not only dependent on the reproductive system of the dam. Calving difficulties are often due to the relatively large birth weight of the calves as well. Considering that body formation has greater heritability than calving problems in general, the question becomes even more involved, particularly in cross breedings. At the same time positive combinations occur as well, because perinatal mortality was found not to be significantly correlated with other important biological traits in cattle. In spite of the fact that no correlation offers itself as a basis for simultaneous selection for pelvic cavity and for the size of the calf (LIBORIUSSEN 1978), it is obvious that the whole question can be evaluated only by considering all these qualities. At the same time a detailed evaluation of veterinary records on calvings is also necessary.

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*

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VARIA II

SOME FACTORS INFLUENCING THE CATCHING OF PLUM FRUIT MOTHS IN SEX PHEROMONE TRAPS

The plum fruit moth [*Grapholitha funebrana* (Treitschke) *Lepidoptera: Tortricidae*) is the main pest of plum orchards in Hungary (SÁRINGER—DESEŐ 1972). Its control depends upon well-timed summer spray applications. Recently sex pheromone traps have become widely used for spray timing. The sex attractant of this pest is cis-8-dodecenyl acetate (Z-8-DDA) (ROELOFS *et al.* 1969, GRANGES—BAGGIOLINI 1971). DELLEY *et al.* (1975) showed the effect of trap type and pheromone rate on catches of male plum fruit moths in Switzerland. In the present paper, the effect of trap type, pheromone releaser, and pheromone rate on the catches of plum fruit moth males are studied.

The trials were carried out in the orchards of the Research Stations of the University of Horticulture, which are located at Kamaraerdő and Laki-hegy. At Kamaraerdő the studies were carried out on an abandoned plum orchard, while in Laki-hegy the studies were carried out on a commercial apricot orchard. The trap type trial was carried out at Kamaraerdő; the pheromone releaser type and pheromone rate studies were carried out at both Kamaraerdő and Laki-hegy. In the trap type trial one Pherotrap 1C (Fig. 1) (Zoecon Corp., CA 94304, USA) and one Reamol trap (Fig. 2) (Reanal Corp., 1147 Budapest, Hungary) were used. The pheromone source used in the two types was the standard Funemone cap (produced by Zoecon Corporation and Murphy Chemical Ltd.). In the trials of pheromone releaser type and rate, comparisons were made between 10 mg (two caps), 5 mg (one cap), and 1 mg, 0.5 mg and 0.25 mg (in sections prepared from polyethylene tube impregnated with Z-8-DDA containing 3.5% of (E) isomer]. The impregnated tube was obtained from Dr. P. J. Charmillot (Research Station, Changins, Switzerland).

The trap type used in trials for determining the pheromone rate was the Pherotrap 1C. The pheromone sources were replaced every 6 weeks throughout the study period. The Pherotraps 1C were routinely cleaned weekly and replaced every 6 weeks or oftener if the sticky surface showed signs of deterioration. The Reamol trap was also routinely cleaned weekly and because the adhesive amount is very small, it was replaced every two weeks. Since the attraction of the compound Cis-8 DDA for plum fruit moth males is not sufficiently specific (COMEAU—ROELOFS 1973, STENMARK 1976, SZIRAKI 1978), specific determinations were confirmed by examination of the male genitalia.

1. Trap design and efficiency

The trial period lasted 23 weeks (from 8th May to 16th October 1979). The weekly catches are given in Table 1.

The results indicated that there was a significant difference between the means of catches in the two types, with Pherotrap 1C being superior to the Reamol trap. This is due to the difference between the two types in dimensions and to the characteristics of the adhesive material. The dimensions of the Pherotrap 1C are given in Fig. 3 and those of the Reamol trap in Fig. 4. In spite of the fact that the two types have the same effective trapping area (approx. 504 sq.cm.) the Pherotrap 1C has a volume of approx. 3310 cu.cm. and a side spacer 5 cm long. The Reamol trap has a volume of approx. 1810 cu.cm. and no side spacer. The catching surface in the Pherotrap 1C is coated with a sufficient quantity of glue which has good viscosity and stickiness and is not affected by weather factors. The adhesive surface in the Reamol trap, however, is coated with too small a quantity of glue which has poorer viscosity and stickiness and is affected by weather factors.

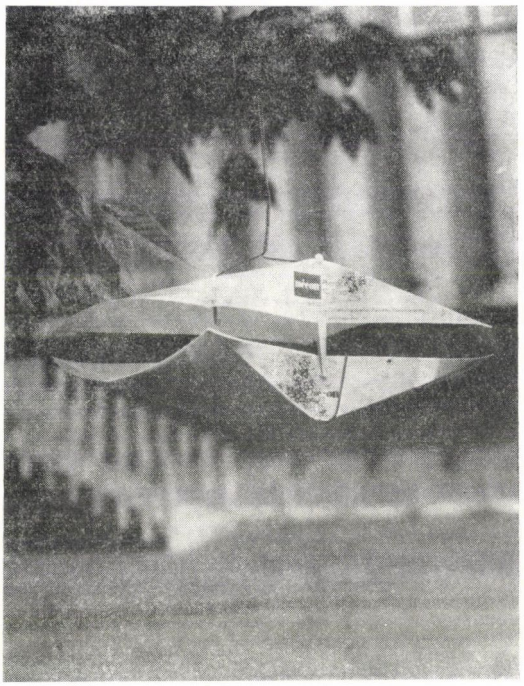

Fig. 1. Pherocon 1C trap (photo: M. El-Adl)

Fig. 2. Reamol trap (photo: M. El-Adl)

Table 1

Number of male plum fruit moths captured in sex pheromone traps of various designs at Kamaraerdő

1979

Date	Trap designs	
	Pherotrap 1C	Reamol
15.5	101	31
22.5	83	27
29.5	51	21
6.6	15	14
12.6	24	10
20.6	21	8
26.6	16	6
3.7	94	41
10.7	126	48
17.7	79	38
24.7	68	21
31.7	63	22
7.8	52	17
14.8	36	11
21.8	18	6
28.8	21	7
4.9	22	6
12.9	11	7
18.9	2	1
25.9	3	1
2.10	2	0
9.10	0	0
16.10	0	0
Total	908	343
Mean of trap catches per week	35.5ab	14.9a

Data were analysed by LSD test; means with different letters are significantly different at the 5% level.

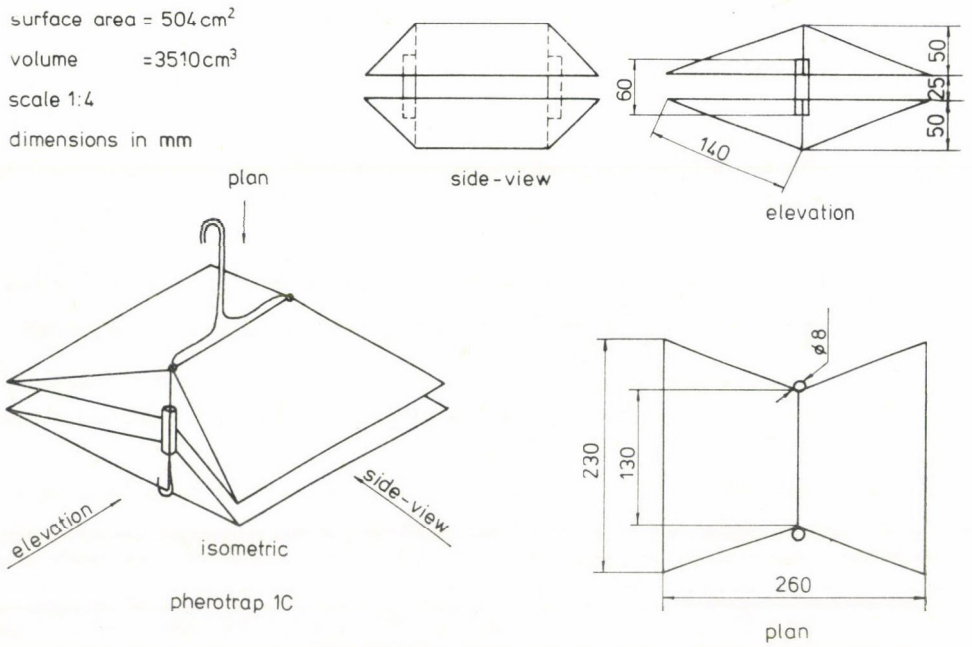

Fig. 3. **Pherotrap 1C, dimensions and surface area**

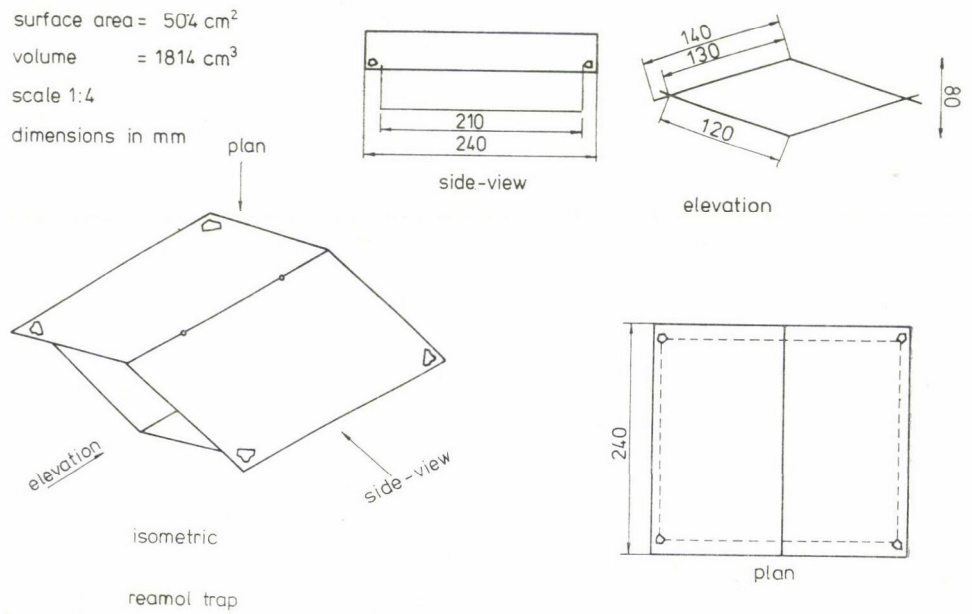

Fig. 4. **Reamol trap, dimensions and surface area**

Tables 2a, b

Number of male plum fruit moths captured in sex pheromone traps (Pherotrap 1C) with different pheromone concentrations and pheromone releasers at Kamaraerdő

1979

	Date	Pheromone concentration and pheromone releaser				
		5 mg Funemone "Zoecon" in polyethylene cap	10 mg Funemone "Zoecon" in polyethylene cap	1 mg Funemone "Swit" in polyethylene tube	0.5 mg Funemone "Swit" in polyethylene tube	0.25 mg Funemone "Swit" in polyethylene tube
a)	15.5	101	67	—	—	—
	22.5	83	66	—	—	—
	29.5	51	34	—	—	—
	6.6	15	28	—	—	—
	12.6	24	13	—	—	—
	20.6	21	13	—	—	—
	26.6	16	4	—	—	—
	3.7	94	58	—	—	—
	10.6	126	72	—	—	—
Total		531	355	—	—	—
Mean of trap catches/week		59*ab*	39.4*a*	—	—	—
b)	17.7	79	28	83	71	29
	24.7	68	43	52	32	11
	31.7	63	29	19	12	9
	7.8	52	46	21	15	7
	14.8	36	68	13	21	9
	21.8	18	58	17	18	13
	28.8	21	42	19	11	8
	4.9	22	19	29	12	7
	12.9	11	3	17	9	2
	18.9	2	0	3	0	1
	25.9	3	2	6	2	1
	2.10	2	1	1	0	0
	9.10	0	0	0	0	0
	16.10	0	0	0	0	0
Total		377	339	280	203	97
Mean of trap catches/week		26.9*a*	24.2*a*	20.0*a*	14.5*a*	6.9*a*

(—) the traps were not hung until after this date.

Data were analysed by LSD test; means with different letters are significantly different at the 5× level.

The results do not agree with those of ROELOFS *et al.* (1973), which indicated that a decrease in trap height opening (types of bottom, and top sections closed, as in the Reamol trap) led to an increase in trap catches. Nor do the results agree with those of LEWIS—MACAULAY (1976) which showed that trap catches increased with the elongation of the pheromone odour plume, as found in closed (top and bottom) trap types; the present results revealed that an omnidirectional trap (top and bottom not closed) with a pheromone odour plume which evaporated in a radial shape (Pherotrap 1C) gave the best catches.

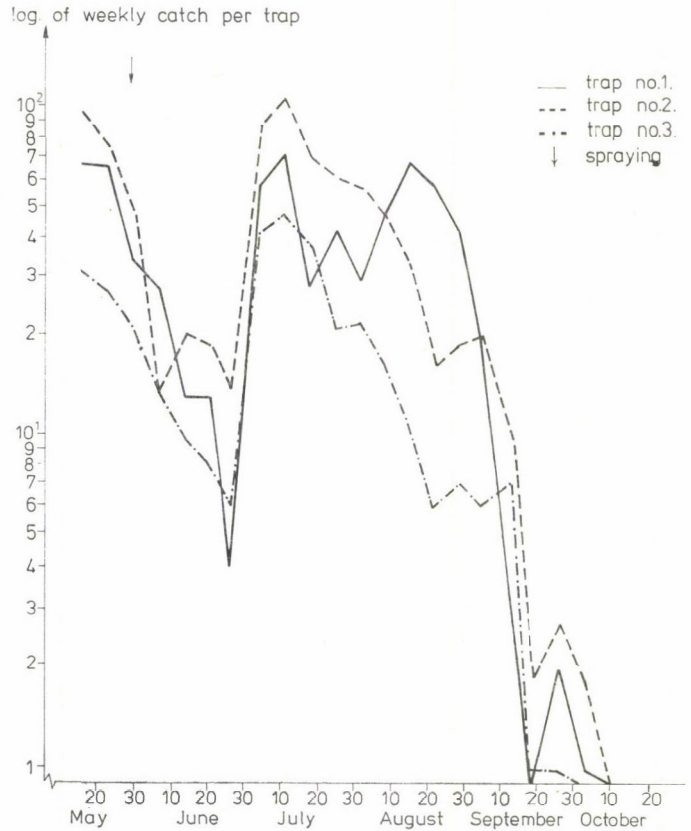

Fig. 5. The plum fruit moth: Seasonal pheromone trapping for 1979 at Kamaraerdő. (Trap No. 1: Pherotrap 1C with one Z cap; trap No. 2: Pherotrap 1C with two Z caps; trap No. 3: Reamol trap with one Z cap)

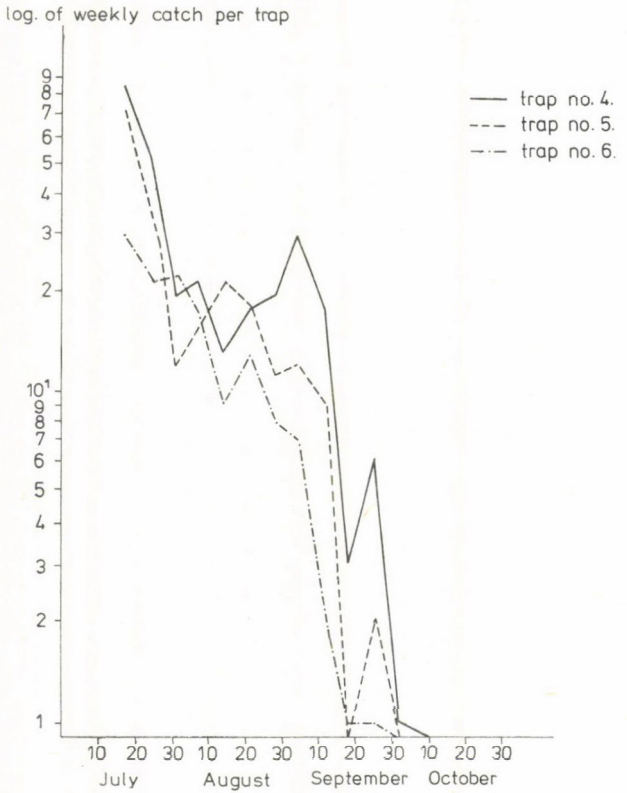

Fig. 6. The plum fruit moth: Pheromone trapping for 1979 at Kamaraerdő. (Trap No. 4: Pherotrap 1C with 1 mg Funemone; trap No. 5: Pherotrap 1C with 0.5 mg Funemone; trap No. 6: Pherotrap 1C with 0.25 mg Funemone)

2. Pheromone rate, dispenser type and trap catch

At Kamaraerdő (abandoned plum orchard)

The study period lasted 23 weeks (from 8th May to 16th October 1979). The weekly catches are presented in Tables 2*a* and *b* and graphically in Figs 5 and 6. In the first nine weeks (until 10th July) pheromone rates of 10 mg (two caps) and 5 mg (one cap) were tested. There was a significant difference between the means of catches for the two rates, the 5 mg

Tables 3a, b

Number of male plum fruit moths captured in sex pheromone traps with different pheromone concentrations and pheromone releases at Laki-hegy

1979

	Date	Pheromone concentrations and pheromone releaser		
		Pherotrap 1C baited with 5 mg Funemone "Zoecon" in polyethylene cap	Pherotrap 1C baited with 10 mg Funemone "Zoecon" in polyethylene cap	Pherotrap 1C baited with 1 mg Funemone "Swit" in polyethylene tube
a)	16.5	78	51	—
	23.5	94	65	—
	30.5	15	22	—
	7.6	9	11	—
	12.6	7	9	—
	20.6	16	11	—
	26.6	12	9	—
	3.7	51	49	—
	10.7	73	62	—
	Total	355	289	
	Mean of trap catches/week	39.4*a*	32.1*a*	
b)	17.7	8	12	63
	24.7	49	32	31
	31.7	12	9	8
	7.8	31	28	33
	14.5	59	50	47
	21.8	58	39	36
	29.8	40	28	32
	4.9	41	36	56
	12.9	7	4	41
	18.9	3	1	2
	25.9	3	1	6
	3.10	0	0	1
	10.10	0	0	0
	16.10	0	0	0
	Total	311	240	356
	Mean of trap catches/week	22.2*a*	17.1*a*	25.43*a*

(—) the trap was not hung until after this date.

Data were analysed by LSD test; means with different letters are significantly different at the 5% level.

rate being more effective. In the second period (which lasted 14 weeks, from 10th July to the end of the trial) besides the previously mentioned rates, 1 mg, 0.5 mg and 0.25 mg were tested in sections of polyethylene tube. There was no significant difference between the means of catches for the five rates, in spite of the high catches in traps baited with 10 mg, 5 mg and 1 mg. It is clear that the 5 mg rate gives the best catch, while the 10 mg rate was less effective than 5 mg, but more effective than 1 mg. The 0.5 mg and 0.25 mg rates gave the lowest catches.

At Laki-hegy (commercial apricot orchard)

The trial period lasted 23 weeks (from 9th May to 16th October 1979). The weekly catches are presented graphically in Fig. 7 and numerically in Tables 3*a* and *b*. In the first period, which lasted 9 weeks (until 10th July) rates of 10 mg and 5 mg were tested using standard caps (Zoecon Corp.); in the rest of the trial period a rate of 1 mg in a section of polyethylene tube was also tested. The results obtained showed that there was no significant difference between the means of catches for the three rates, but the 1 mg rate (in a polyethylene tube) was equally as effective as the 5 mg rate (standard Funemone cap). The 10 mg rate showed the lowest efficacy, due to flight response inhibition.

From the above results the following conclusion could be drawn. The type of trap. the shape and the surface area affect the size of the male plum fruit moth catch. The Pherotrap 1C is a convenient type with respect to the size of catch compared with the Reamol type.

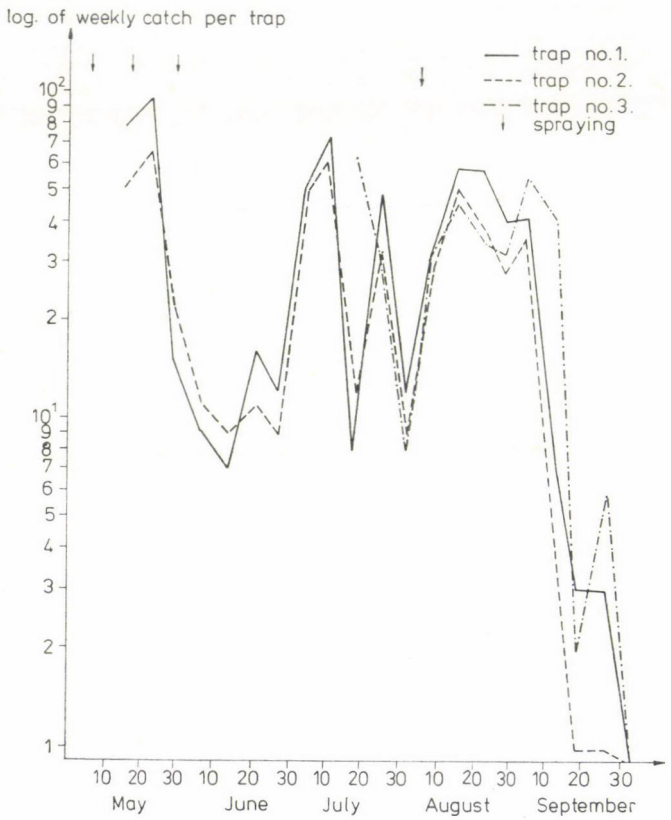

Fig. 7. The plum fruit moth: Seasonal pheromone trapping for 1979 at Lakihegy. (Trap No. 1: baited with one Z cap; trap No. 2: baited with two Z caps; trap No. 3: baited with 1 mg Funemone)

A pheromone rate of 5 mg proved more attractive than 10 mg, due to the inhibiting effect of pheromone at higher rates. The 1 mg rate in a polyethylene tube gave bigger catches than 5 mg and 10 mg in polyethylene caps. In general, from the practical point of view, using rates of Funemone ranging from 0.5 to 5 mg gave similar results.

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STUDIES ON STALK ROT IN RELATION TO MATURITY AND APPLIED FERTILIZERS IN MAIZE

Stalk rots are universally important and are among the most destructive diseases of maize throughout the world. Many fungal and bacterial organisms invade roots and stalks, where they cause premature dying of plants and reduced stalk strength.

Saprophytic fungi are more efficient in rotting dead stalks than are parasitic fungi (Amosu—Hooker 1970, Christensen—Wilcoxson 1966, Koehler 1960, Manninger 1969b). Identification of a specific stalk rot pathogen is, therefore, difficult.

Losses vary from season to season and from region to region. Yield losses are both direct (poor grain filling or lightweight and poorly finished ears) or indirect through stalk breakage during mechanical harvesting or lodging, as indicated by Manninger—Dolinka (1966).

The development of stalk rots is favoured by dry weather early in the growing season followed by extended periods of rainfall shortly after silking. Unbalanced fertility, low potassium (K), poor soil drainage, mechanical and insect damage, variety or hybrid, plant density, plant maturity, soluble solids content, pith condition and other factors all influence disease prevalence and severity.

Hooker (1977) suggested that breeding for resistance is the most effective means of reducing losses due to stalk rots when maize is intensively cultivated.

COMSTOCK—MOLL (1963) defined the genotype-environment interaction as the differential response of phenotypes to changes in the environment. They classified environments in two categories: macro- and micro-environmental variations. Macro-environmental variation is caused by fluctuations in variables which have large and easily recognized variations (i.e. year, location, fertility, planting date, plant density), whereas micro-environmental variations arise from plant to plant variations within the macro-environments.

ODIMEH—EL-ROUBY (1973) found that non-stress or higher productivity conditions enhanced genetic variability among single crosses, while stress environments reduced the genetic variability. This concept had been recognized earlier by plant pathologists while selecting for resistant genotypes. The disease reaction of the tested genotypes is usually examined under artificial inoculation conditions where the rate of infection is high; the artificial inoculation environment is a non-stress environment with respect to disease reaction while it is a stress environment with respect to the inoculated plants. WALKER (1966) reviewed the various techniques used by plant pathologists to identify the best environment for differentiation. All the cited examples could be considered as optimum environments for pathogens.

The objective of the present study was to determine the effects of fertilizer application on stalk rot, to identify the characteristics of the optimum conditions for the evaluation of single crosses of maize with respect to resistance or susceptibility to stalk rot, and to estimate the relation between lodging and maturity.

The experiments were carried out in the nursery of the Agricultural Research Institute of the Hungarian Academy of Sciences at Martonvásár, Hungary, during the two growing seasons of 1978 and 1979. Seven inbred lines were selected according to their importance and were used in this study. (The line D_2 matured too late and the crosses were not successful.)

The following is the pedigree and designation of the selected lines:

Designation	Pedigree	Maturity	Source
1. D-1	K 6	very late	Egypt
2. D-3	MR 18	early	Hungary
3. D-4	MR 4	very early	Hungary
4. D-5	B 14	late	USA
5. D-6	Synthetic S_5	late	USA, Hungary, East Germany, Tanzania, Mexico
6. D-7	Synthetic S_4	late	USA, Hungary, Tanzania, Vietnam, Mexico
7. D-8	F 564	early	USA

All possible single crosses were made between the seven inbred lines in 1977, resulting in 21 hybrids.

The purpose of this study was to test the effect of genetic variations among single crosses and the effect of a change in soil fertility on the rating of stalk rot disease by natural infection.

Three different environments were used for this study, as follows:

1. C: Balanced fertilizers; NPK (1 : 1 : 1)
2. M: Unbalanced fertilizer; nitrogen only
3. R: Without fertilizers for many years (infertile soil) in a naturally and artificially infected field (provocation).

Every environment formed an independent experiment. Each experiment was designed as a randomized complete block with two replications. The 21 single crosses and the check hybrid were assigned at random within each block. Each plot consisted of two rows 6 m long $\times$ 0.7 m wide. The distance between hills was 30 cm. The hills were thinned to one plant per hill.

Experiments C and M were sown on April 26th in 1978 and on April 17th in 1979, while experiment R was sown on May 6th in 1978 and on April 26th in 1979. All the agricultural processes were carried out according to those usually used under the local conditions.

For estimation of maturity the character "drying date of ear husks" was used. This was expressed as the number of days from planting to the day when more than 90% of the ear husks per plot had dried.

Data for stalk rot rate were taken during harvest on individual plants on November 10th for experiments C and M and at the end of November for experiment R in 1978, and in the middle of October for all three experiments in 1979.

Each single cross was scored for stalk-rot reaction using a 1 to 9 visual scale based on the lodging of plants, ranging from 1 = stalk upright (no infection visible) to 9 = whole stalk is lodged on the ground or prematurely killed plants, as given by MANNINGER (1977).

At the same time, for experiment M the stalk rot rate was determined after harvest in the middle of November in 1978 by cutting the lower portion of the stalks for scoring from 1 to 9 (1, 3, 5, 7, 9), as recommended by the European FAO Sub-network for maize resistance to *Fusarium* spp.

The analysis of variance was calculated on plot means. The data from each experiment were analysed independently. The three experiments were combined in one analysis of variance for each year. As the error variance was heterogeneous in the two years, the analysis of variance for each year will be presented separately.

The stalk rot values in the three environments were considered as three random variables. The formula for the correlation coefficient was given in SNEDECOR—COCHRAN (1967).

The results obtained were divided into four parts: 1. Comparison between the two scales used for stalk rot determination. 2. The relation between maturity and stalk rot. 3. The effect of applied fertilizers on stalk rot disease. 4. Environmental and genetic variations

1. Comparison between the two scales

In most cases, rots are caused by a complex of several species of fungi and bacteria that attack plants approaching maturity. MANNINGER (1969a) and KOVÁCS (1973) found strong stalk rot infection of maize associated with lodging, causing a significant yield loss in seed and commercial crop production, and established that lodging had become a serious problem in overmaturing maize. MANNINGER (1977) indicated that the first signs of disease, which are sudden withering, followed by gradual lodging, do not generally appear until after the milky-waxy stage of ripening, and used a scale ranging from 1—9, applied on individual plants, to determine the resistance or susceptibility to stalk rot. This scale is described in detail with the help of diagrams.

The European FAO sub-network recommended a 1—9 (1, 3, 5, 7, 9) scale for stalk rot determination, but the lower portion of the stalks must be cut longways for scoring and symptoms are also described. In experiment M the degree of stalk rot infection was determined after harvest in the 1978 season using both scales on the same plants after natural infection.

First the visual scale was used on the basis of lodged plants, then the FAO scale was used by cutting the stalks longitudinally to note the disintegration of nodes or internodes.

The correlation between the two scales was positive and highly significant, with an r value of 0.66.** This means that there is no significant difference between the two scales.

Therefore, it may be concluded that the visual scale is suitable for use by maize breeders because the disease can be easily determined and multiple genotypes can be rapidly differentiated.

2. Relationship between stalk rot and maturity

The main problem for the breeder is to overcome the negative correlation between earliness and productivity. The relationship between development and growth must be modified.

In this study, the character "drying date of ear husks" was used for the estimation of maturity (ODIMEH—MANNINGER 1979) and the visual scale (1—9) was used for stalk rot determination. The correlation coefficient between stalk rot and maturity was calculated with respect to experiment M only in both seasons. The results showed that the correlation coefficient between stalk rot disease and the number of days from sowing to drying of husks, which indicates the maturity, was negative and highly significant, with values of —0.71** in the 1978 season and —0.70** in the 1979 season.

The same trend is evident from Figs 1 and 2, for 1978 and 1979, respectively. These figures indicate that the stalk rot rate was positively related with earliness. ODIMEH—MANNINGER (1979) found that early hybrids were susceptible to stalk rot, while late hybrids seemed to be resistant to this disease. It may be concluded that earliness is an important factor in susceptibility to stalk rot disease.

On the other hand, early maturity of maize is often associated with low grain yields and/or poor stalk quality. One reason for this association could be the too low photosynthetic rate during grain filling. If the demand of the developing ear and grain for photosynthates is high and if the photosynthetic rate is too low to supply this demand, stored photosynthates (i.e. carbohydrates) will be transferred from the stalk to the grain. This reduction in stalk carbohydrates, in turn, will reduce stalk strength and predispose the plants to disease. If, however, the photosynthetic rate is high enough to meet the demand, high grain yield and good stalk quality will result.

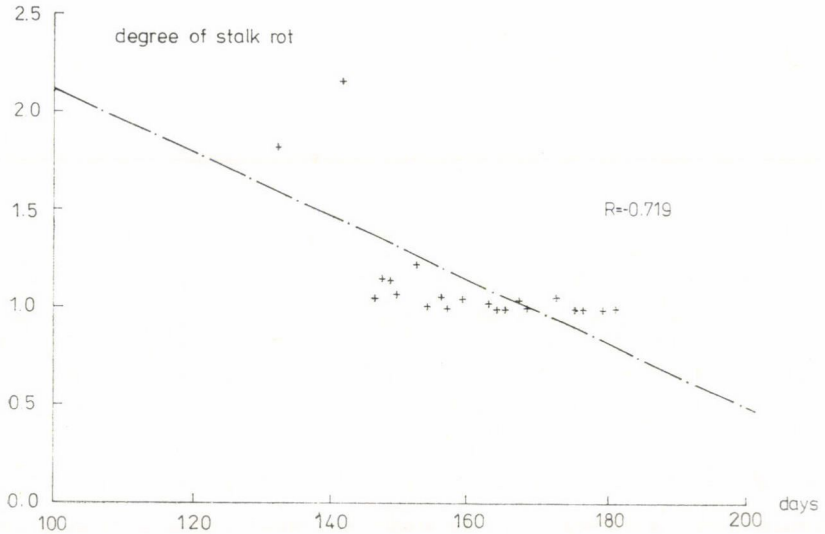

Fig. 1. Relation between earliness and stalk rot, 1978

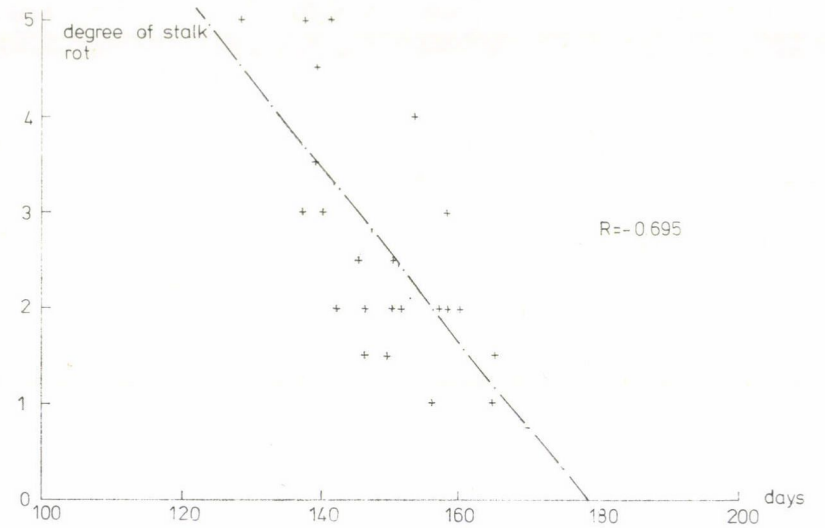

Fig. 2. Relation between earliness and stalk rot, 1979

Recently, it has been shown that the photosynthetic rate (i.e. CO_2 exchange rate) in maize is hereditary and that selection advance for the trait can be achieved as indicated by Mock (1979).

3. The effect of applied fertilizers on stalk rot

The means of the stalk rot for the three environments in the two seasons are given in Table 1.

Stalk rot infection varied from season to season and from one environment to the other and responded to the change in the soil fertility in the three environments. Generally, in the 1978 season the hybrids could be considered more resistant than in the 1979 season.

Table 1

Mean of the stalk rot character for the diallel cross in the different environments in the two seasons

Year	Environments		
	C	M	R
1978	1.07	1.70	3.11
1979	1.66	2.75	3.14
Mean	1.37	2.23	3.13

The results showed that stalk rot disease increased considerably with unbalanced fertility when only nitrogen fertilizer was used, with low potassium (K), and on soil without applied fertilizer (infertile soils).

Stalk rot reached the maximum level in the case of environment R (without fertilizers) and the minimum level in the case of environment C (NPK). This is similar to the results indicated by MANNINGER (1977). It may be concluded that environments R and M could be considered as non-stress environments, while C was considered as a stress environment for stalk rot disease.

4. Environmental and genetic variations with respect to stalk rot disease

The estimates of environmental variances and genotypic variances were calculated for each environment.

The effect of the different environments was examined with respect to the following criteria:

1. the magnitude of experimental error,
2. mean square of entries,
3. the magnitude of the F-ratio (JAMES *et al.* 1976).

Estimates of error variance and variations between single crosses for different environments are given in Table 2. The magnitude of error variance was affected by fertility and

Table 2

Part of the analysis of variance of stalk rot for the diallel cross under different environments in the two seasons

Source of variations	d.f.	C		M		R	
		M.S.	F.	M.S.	F.	M.S.	F.
1978							
Entries	21	0.69	1.92^{NS}	3.27	12.98**	3.39	3.43**
Error	21	0.36		0.25		0.99	
C.V.%		35		17		31	
1979							
Entries	21	0.062	0.89^{NS}	0.65	3.6**	3.23	4.6**
Error	21	0.07		0.18		0.70	
C.V.%		25		25		27	

** Significant at the 0.01 level of probability.

differed from one environment to another; the error variance was smaller for environments C and M than for environment R in both seasons.

The smallest error was in environment C in 1979, while the largest error was associated with environment R. In general the error variance was considerably higher in the 1978 than in the 1979 season.

As regards genetic variations between the tested genotypes, the mean square of entries was significant in all environments except in environment C in both seasons.

This would indicate that the variations between entries with respect to stalk rot can be easily recognized in both environments M and R. However, the magnitude of the F-ratios would indicate the relative sensitivity of the environment. The data showed that environment C was the best for resistance while the two other environments were almost identical in favouring the development of stalk rot disease.

It may be concluded that the optimum environment for the determination of stalk rot was either environment R or M, while C was a stress environment for stalk rot disease.

The combined analysis of variance is shown in Table 3. The interaction between environment and genotype indicates a different response of the genotypes to the change in susceptibility level. The high significance of the environments means that the disease gave a response to the change in fertilizers in the three environments.

The variations between single crosses were highly significant and larger in 1978 than in 1979. This would indicate that the magnitudes of the genetic variations were not consistent in the different environments, but were different in the tested environments. The interaction of the entry with unbalanced soil fertility was significant.

The genotype × environment interaction may be due to the fact that the environment curtails or expands the variations between genotypes without changing the order of the different genotypes, or it might be the result of changes in the order of the different genotypes.

Table 3

Part of the analysis of variance of stalk rot combined over the three environments for the diallel cross in the two seasons

Source of variations	d.f.	1978		1979	
		M.S.	F.	M.S.	F.
Replic./groups	3	1.16	2.19^{NS}	0.63	2.03^{NS}
Environments	2	25.83	48.74**	28.22	91.03**
Entries	21	5.49	**10.36****	1.90	6.13**
Entries × Environ.	42	0.93	**1.75***	1.02	3.29**
Error	**63**	0.53		0.31	

*, ** Significant at the 0.05 and 0.01 levels of probability, respectively.

Table 4

Correlation coefficients between stalk rot performances of the single crosses in the different environments

Environments		M		R	
		1978	1979	1978	1979
(NPK)	C	0.69**	0.82**	0.34^{NS}	0.24^{NS}
(N)	M			0.47*	0.68**
(—)	R				

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.

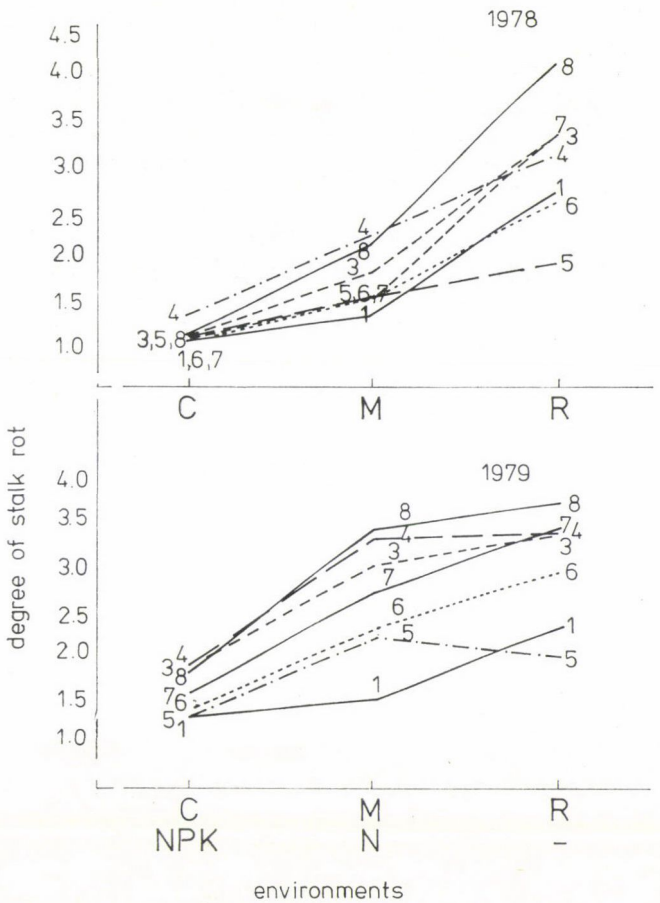

Fig. 3. Average stalk rot for the lines under the three environments in the 1978 and 1979 seasons

It may be concluded that resistance or susceptibility to stalk rot was highly affected by environment with respect to the genetic differences.

The differences between the types of interactions could be studied by calculating the correlations between the means of the different genotypes in different environments. These correlations are presented in Table 4.

The low correlation coefficients were not significant between environments C and R, while the high correlation coefficients were highly significant between M and the other two environments. However, the magnitude of the correlation indicated that there was a change in the order of the genotypes in the different environments.

It may be concluded that M was the optimum environment for the assessment of stalk rot disease, as this environment was in high positive correlation with both the farm environment (C), which was considered as a stress environment for the disease, and with the non-stress environment in the naturally infected field (R).

The average performances of the different lines in the single cross were plotted for the different environments in each season and are presented in Fig. 3.

The differential performance among the seven lines was maximum in environments M and R, while the variations were minimum for environment C. In general, the relative order of the seven lines was similar in the two environments (M, R). However, line D-8 was consistently susceptible in environments M and R and lines D-1 and D-5 were consistently highly

resistant in the three environments. It may be stated in summary that maximum genetic differentiations to stalk rot reaction were obtained in environments M and R in both seasons. Lines D-3, D-4, D-6 and D-7 responded similarly to the change in the three environments, while lines D-1, D-5 and D-8 showed a different response to the change in the environments. This might explain the interaction between environment and genotypes with respect to stalk rot by natural infection.

From these studies it seems that the optimum environment for evaluation should be characterized by the following features:

1. maximum genetic variance
2. minimum estimate of error variance so that the genotypes can be differentiated with the least number of replications
3. positive correlation with the optimum environment for farm production.

The optimum environment for the determination of stalk rot was the nitrogen fertilizer environment (M), which was considered a non-stress enviroment with respect to the disease.

It might be concluded that the non-stress condition permitted a greater degree of genetic differentiation among the tested genotypes, while the stress condition curtailed or limited the genetic differences among the genotypes. These findings are in accordance with the results reported by FREY (1964), JOHNSON—FREY (1967) and VELA-CARDENAS—FREY (1972), who showed that the maximum expression of genetic variability was attained in a non-stress environment.

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RICE HULLS IN THE NUTRITION OF RUMINANTS
II. UTILIZATION OF RICE HULLS BY LAMBS

Rice is produced in several countries on a large scale. Some of these countries suffer from a shortage of animal feed. Rice hulls (RH), a by-product of the rice industry, could be used as a source of roughage in such countries. The possibility of feeding this material to ruminants must be thoroughly investigated.

Attempts to use RH as a ruminant feed were made by several workers (Jones *et al.* 1938, Noland—Gainer 1953, Roy—Child 1963, cit: HUTANUWATR *et al.* 1974). Cattle feeders are interested in this product as a roughage in mechanized feedlots (WHITE 1966). Moreover, TILLMAN *et al.* (1969) studied the utilization of RH in cattle finishing rations. FAHMY *et al.* (1968), investigated the effect of replacing part or all of the wheat straw with ground RH on the performance of lambs. Noland—Gainer (1953) could not find any histopathological evidence of damage to the digestive tract in sheep fed on RH (reviewed by MCMANUS—CHOUNG 1976).

The low feeding value of RH can possibly be accounted for by its very low water-soluble nutrient content and relatively high content of silica and lignin (HUTANUWATR *et al.* 1974). In earlier investigations it was found that 98% of the silica intake was excreted in the faeces (MAHMOUD *et al.* 1982). ENG (1964) and WHITE (1966) studied ammoniated RH with a view to increasing its nutritive value. The results published by ENG (1964), FURR—CARPENTER (1967) and TILLMAN *et al.* (1969) indicated that low levels of ammoniated RH or crude RH plus urea may be used to replace ground sorghum grain in high grain bovine fattening ratios without a significant reduction in the feeding value of the total ration.

Thus, it appeared desirable to determine the value of crude RH as the sole source of roughage, when fed to lambs with or without urea. The results presented in this paper establish the effect of feeding RH on digestibility, nitrogen retention and some blood nitrogen parameters.

Three Merino wether lambs with an average weight of 28 kg and aged about 6 months were fitted with ruminal canulae for use in this experiment. The lambs were put into the metabolism cages and subsequently fed three different diets for a ten-day preliminary period and a five-day collection period. The dietary treatments were the same as those reported in the first experiment (MAHMOUD *et al.* 1982).

Before mixing the RH with the other ingredients it was cracked in a mixer in order to break the hulls into about two pieces. Diets were fed twice daily while salt blocks and water were offered ad libitum to each animal.

Nitrogen was determined using the Kjeldahl method in urine and faeces during the collection period for the determination of the nitrogen balance. Ten percent of the faeces was taken daily and dried for digestibility determination. Since RH are considered to be low quality roughage, it was found necessary to determine the digestion of neutral detergent fibre (NDF) and acid detergent fibre (ADF). Analyses of feedstuff and faeces were carried out according to ANONYMOUS (1965).

NDF, ADF and lignin were measured using the procedure describe by VAN SOEST—WINE (1967). The chemical analysis of the different ingredients is presented in Table 1.

On the last three consecutive days during each collection period, 50 ml rumen fluid were taken 3 hr after feeding through the ruminal canulae and at the same time blood samples were withdrawn from the jugular vein. The following measurements were made on each animal: rumen fluid and blood ammonia, according to the microdiffusion technique described by JUHÁSZ—SZEGEDI (1958), blood urea, according to VELŐSY—SZABÓ (1972), and total protein and amino acid nitrogen in the blood plasma, as described by BÁLINT (1962).

The digestibility and nitrogen retention of the different diets are presented in Table 2. Dry matter digestibility decreased from 71.1% (control diet, I) to 63.9% (diet II.) as a result of feeding RH, but the digestibility increased to 77.3% when RH was supplemented with urea (diet III).

Table 1

Chemical composition of the different ingredients as a percentage

	Barley	Barley straw	Rice hulls	Molasses
Dry matter	90.7	95.6	93.1	82.1
Crude protein	15.0	5.0	5.1	12.4
Ether extract	2.0	1.5	0.8	—
Crude fibre	3.6	44.2	38.9	—
Nitrogen-free extract	67.6	39.2	32.9	63.4
Silica-free ash	2.15	3.01	0.93	6.3
Silica (SiO_2)	0.35	2.69	14.43	—
Nuetral detergent fibre (NDF)*	18.5	81.0	94.9	—
Acid detergent fibre (ADF)*	6.5	51.5	65.2	—
Lignin*	—	9.5	23.0	—

* On a dry matter basis.

Table 2

Nitrogen balance and digestibility for lambs as affected by the different treatments

Nitrogen balance (g/day)	Treatment I				Treatment II			Treatment III		
	Lamb No.			mean	Lamb No.		mean	Lamb No.		mean
	1.	2.	3.		2.	3.		2.	3.	
Nitrogen intake (g/day)	16.52	16.60	15.97	16.36	17.03	17.03	17.03	21.70	21.70	21.70
Urinary N (g/day)	3.25	7.80	6.84	5.96	11.31	7.66	9.49	8.24	10.10	9.17
Faecal N (g/day)	6.28	5.75	6.03	6.02	4.80	4.59	4.69	2.93	4.64	3.79
Nitrogen balance (g/day)	+6.99	+3.04	+3.10	+4.38	+0.92	+4.79	+2.85	+10.54	+6.96	+8.74
Nitrogen retention as % of intake	42.3	18.3	19.4	26.7	5.4	28.1	16.7	48.6	32.1	40.3
Digestibility coefficients, %										
Dry matter	69.3	71.0	72.9	71.1	63.4	64.5	63.9	82.2	72.4	77.3
Protein	62.0	65.4	62.2	63.2	71.8	73.1	72.5	86.5	78.6	82.6
Nitrogen-free extract	80.1	80.5	82.1	80.9	84.9	85.1	85.0	87.9	86.9	87.4
Crude fiber	32.8	41.4	35.0	36.4	4.9	6.0	5.5	35.4	17.1	26.3
NDF	36.3	39.1	38.7	38.0	18.1	22.6	20.4	43.3	32.5	37.9
ADF	26.4	32.8	29.3	29.5	0.0	6.6	3.3	32.4	18.0	25.2

Table 3

Ruminal ammonia and blood parameters as affected by the different dietary treatments

Treatment		Lamb			Average of three lambs
		No. 1	No. 2	No. 3	
I.	Ruminal ammonia (mg/100 ml)	13.0 ± 1.07	8.7 ± 0.97	7.7 ± 0.29	9.8 ± 2.81
	Blood ammonia (μg/100 ml)	174 ± 13	163 ± 20	151 ± 16	163 ± 11.50
	Plasma urea (mg/100 ml)	24.4 ± 1.15	43.4 ± 6.5	44.8 ± 2.64	37.5 ± 11.39
	Plasma amino-acid-N (mg/100 ml)	9.8 ± 0.06	7.1 ± 1.42	9.1 ± 0.41	8.7 ± 1.40
	Plasma total protein (g/100 ml)	6.2 ± 0.57	6.2 ± 0.78	6.7 ± 0.12	6.4 ± 0.28
II.	Ruminal ammonia (mg/100 ml)	12.6 ± 2.47	8.0 ± 0.44	11.0 ± 1.67	10.5 ± 2.33
	Blood ammonia (μg/100 ml)	135 ± 10	128 ± 14	141 ± 25	135 ± 6.50
	Plasma urea (mg/100 ml)	57.9 ± 1.59	48.6 ± 4.19	41.6 ± 7.35	49.4 ± 8.17
	Plasma amino acid-N (mg/100 ml)	6.0 ± 0.28	5.7 ± 1.18	6.9 ± 1.47	6.2 ± 0.62
	Plasma total protein (g/100 ml)	6.7 ± 0.27	5.5 ± 0.63	6.2 ± 0.13	6.1 ± 0.60
III.	Ruminal ammonia (mg/100 ml)	20.7 ± 4.53	27.1 ± 3.62	17.4 ± 4.46	21.6 ± 4.93
	Blood ammonia (μg/100 ml)	164 ± 21	125 ± 14	135 ± 16	141 ± 20.25
	Plasma urea (mg/100 ml)	42.7 ± 1.32	64.4 ± 14.79	53.4 ± 8.63	53.5 ± 10.85
	Plasma amino acid-N (mg/100 ml)	9.4 ± 0.88	9.8 ± 1.12	9.5 ± 0.81	9.6 ± 0.20
	Plasma total protein (g/100 ml)	6.8 ± 0.12	6.3 ± 0.40	6.2 ± 0.32	6.4 ± 0.32

Each value is the mean ± standard error of three observations taken three hours after feeding on 3 consecutive days.

All animals were in positive nitrogen balance after the different dietary treatments. Nitrogen retention decreased when RH was used to replace straw. However, the retention of nitrogen increased when RH was fed together with supplementary urea (diet III). The nitrogen retention as a percentage of nitrogen intake was 26.7, 16.8 and 40.4% for diets I, II and III, respectively. The increase in nitrogen retention obtained for the animals in treatment III was due to the beneficial effect of urea as a source of nitrogen in improving the utilization of RH.

Crude fibre digestibility increased from 5.5% in diet II to 26.3% in diet III. The digestibility of NDF and ADF also increased from 20.4 and 3.3% (diet II) to 37.9 and 25.2% (diet III), as shown in Table 2. It was also interesting to note that the digestibility of NDF was the same in the control diet I and in diet III (38.0 and 37.9%, respectively).

It seems that the effect of ammoniating RH (ENG 1964, WHITE 1966) or of treating RH with alkali (CHOUNG—McMANUS 1976) in increasing its nutritive value resembles the effect of urea in the present study. The results of CAMPLING *et al.* (1962), RALEIGH—WALLACE (1963) and BHATTACHARYA—PERVEZ (1973) indicated that the supplementation of low quality roughages with non-protein nitrogen (NPN) improved their digestibility and stimulated dry matter intake.

It was observed that ground RH, when heated in the presence of ammonia and catalysts, would absorb ammonia, resulting in a product containing about 1.6% nitrogen. FURR—CARPENTER (1967) and WHITE (1966) indicated that this product is of value when fed at low levels in high-grain fattening rations for cattle. It is suggested that the beneficial effect of urea when fed with RH, was due to the resultant release of ammonia in the rumen; this was then absorbed by the RH, thereby producing ammoniated RH, which was more available to be attacked by the ruminal microorganisms. This suggestion is based on the higher level of ammonia concentration in the rumen obtained from treatment III (21.6 mg/100 ml) than that obtained from treatment II (10.5 mg/100 ml) (Table 3). But the synthesis of absorbed ammonia to urea in the liver only resulted in a slight increase in blood urea level in treatment III (53.5 mg/100 ml), compared with 49.4 mg/100 ml in treatment II. Moreover, the level of amino acid-N in the blood plasma increased from 6.2 mg/100 ml in treatment II to 9.6 mg/100 ml in treatment III; the latter figure was slightly higher than that found in control diet I (8.7 mg/100 ml). The results also indicated that in spite of the fact that the concentration of ruminal ammonia in treatment III was about twofold that in treatment II, the level of blood ammonia did not increase in treatment III. The levels of blood ammonia were 163, 153 and 141 μg/100 ml, respectively, for dietary treatments I, II and III. The corresponding figures for plasma total protein were 6.4, 6.1 and 6.4 g/100 ml (Table 3). These results were confirmed by the data obtained from the nitrogen balance, since the proportion of nitrogen retained was 16.8% when RH was fed without urea, but the retention increased to 40.4% when 10 g urea was fed daily in combination with RH.

It was concluded that RH was deficient in nitrogen, thus restricting bacterial growth. When supplementary nitrogen (urea) was added, it stimulated bacterial growth in the rumen and increased the utilization of RH. Moreover, replacing the straw with RH supplemented with urea did not result in any reduction in the feeding value of the ration.

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DIGESTA COMPOSITION OF CHICKENS FED DIFFERENT FINAL MOLASSES LEVELS IN THE DIETS

Research work on the use of final molasses in diets for fattening chickens have been mainly based on nutritional performance trials for determining the optimum substitution levels of cereals by final molasses (ROSENBERG—PALAFOX 1956, PÉREZ—PRESTON 1970, CONNOR *et al.* 1972, GONZÁLEZ—IBÁÑEZ 1973a, b). However, few studies on the digesta characteristics within the gastrointestinal tract (GIT) of the birds or on the digestibility of some nutrients when fed with this by-product have been carried out.

Animals. Thirty male Cornish × White Plymouth Rock × Barred Plymouth Rock chickens were used in a completely randomized design for studying five diets with an average of six birds per treatment.

Diets. These consisted of a maize basal control diet and four others, where this cereal was gradually substituted by final molasses (16.0, 31.8, 46.4 and 65.7% of the diet DM). The composition of the diets was the same as that reported by ALVAREZ (1975).

Experimental procedure. The birds were slaughtered at the end of the fattening period between 45 and 60 min after the morning feed by means of an intravenous injection of thiopenithol. This time interval was strictly controlled throughout the experiment. An incision was made in the birds' abdomen for the GIT exposition. Afterwards the following sections of

Table 1

DM variations (%) in various sections of the GIT of chickens fed different levels of final molasses in the diet

Final molasses % in the diets	Crop	Proventricle gizzard	Small intestine	Caeca
0.0	39.5^{d}	45.4^{a}	18.0^{d}	17.0
16.0	37.4^{d}	38.0^{b}	14.4^{c}	16.5
31.8	32.5^{c}	34.2^{c}	13.6^{c}	17.5
46.4	27.5^{b}	25.1^{d}	12.2^{b}	17.3
95.7	22.1^{a}	18.0^{e}	8.9^{a}	15.2
SE	±1.3***	±1.1***	±0.4***	±1.0

^{abcd} Means without letters in common within the same column differ significantly at $P < 0.05$.
*** $P < 0.001$.

Table 2

Ash variations (%) in various sections of the GIT of chickens fed different levels of final molasses in the diet

Final molasses % in the diets	Crop	Proventricle gizzard	Small intestine	Caeca
0.0	2.9^{a}	1.6^{a}	10.8^{a}	15.6^{a}
16.0	5.1^{b}	2.6^{b}	9.8^{a}	15.9^{ab}
31.8	8.7^{c}	3.0^{b}	11.6^{b}	17.4^{c}
46.4	10.6^{cd}	3.0^{b}	17.6^{c}	15.5^{a}
65.7	11.9^{d}	8.1^{c}	17.9^{c}	16.9^{bc}
SE	$\pm 0.5^{***}$	$\pm 0.2^{***}$	$\pm 0.4^{***}$	$\pm 0.4^{**}$

^{abcd} Means without letters in common within the same column differ significantly at $P < 0.5$.
** $P < 0.01$.
*** $P < 0.001$.

Table 3

N variations (%) in various sections of the GIT of chickens fed different levels of final molasses in the diet

Final molasses % in the diets	Crop	Proventricle gizzard	Small intestine	Caeca
0.0	2.2^{a}	2.1^{b}	5.6	2.8^{a}
16.0	2.3^{a}	2.2^{b}	4.7	3.9^{b}
31.8	2.9^{b}	2.2^{b}	4.9	5.7^{c}
46.4	2.6^{ab}	2.2^{b}	3.4	4.5^{b}
65.7	3.6^{c}	3.7^{c}	4.6	5.4^{c}
SE	$\pm 0.2^{***}$	$\pm 0.1^{***}$	± 0.5	$\pm 0.2^{***}$

^{abcd} Means without letters in common within the same column differ significantly at $P < 0.05$.
*** $P < 0.001$.

the GIT were ligated and carefully extracted: crop (Cr); proventricle-gizzard (PG); small intestine (SI) and caeca (C).

The digestive contents in each of the extracted sections of the GIT were collected and treated for subsequent analysis according to the methods described by ALVAREZ (1975).

Chemical analyses. DM, ashes and nitrogen of the digestive contents were determined following the techniques of the AOAC (ANONYMOUS 1965), and total reducing sugars according to NELSON (1944).

Statistical analyses. The experimental results obtained were analysed using simple classification models, utilizing DUNCAN's (1955) multiple range test for the mean comparisons when necessary.

A significant difference ($P < 0.001$) was found between the dry matter values in the digestive contents of Cr, PG and SI depending on the final molasses levels employed. In most cases a tendency towards a decrease in these values was manifested with an increase in the molasses levels of the diets (Table 1). No significant differences were found in the caeca.

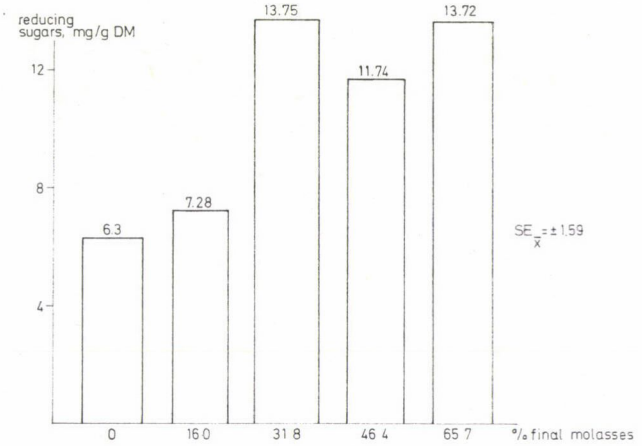

Fig. 1. **Total reducing sugar content mg/g DM in the caeca of chickens fed different final molasses levels in the diet**

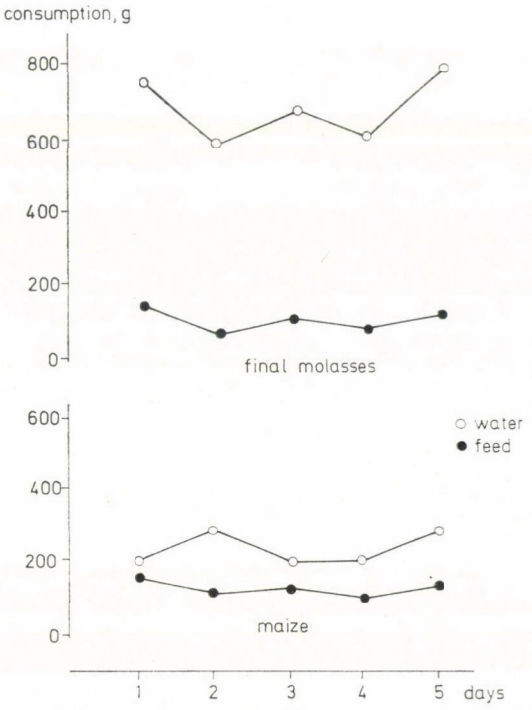

Fig. 2. **Variations in water and feed consumption of chickens fed maize or final molasses**

Table 2 shows the values of the ash contents in each of the GIT sections. A significant increment ($P < 0.01$ and $P < 0.001$) was found with the increasing molasses levels in the rations. The values of the nitrogen contents in the different sections studied show a significant increase ($P < 0.001$) in the case of Cr, PG and C with an increase of molasses in the diets (Table 3). In the small intestine these values did not show significant differences.

The results of the total reducing sugar contents (Fig. 1) showed an increase in the highest molasses treatments in comparison to the maize control diet.

The decrease in the dry matter values of the digestive contents with the progressive increase of the final molasses levels in the rations seems to be related to the increase in water consumption by the birds (Fig. 2), which per se tends to increase the degree of dilution of the GIT digestive contents.

The considerable increase in ash contents in the different GIT sections studied seems partly to explain the drop in the apparant DM retention and the organic matter of the chickens that consumed final molasses (ALVAREZ 1975).

The increase in the nitrogen contents along the GIT of the birds as the final molasses levels in the rations increased seems to be directly related to the protein supplement distribution in the energetic phase, and the greater rate of passage of the liquid phase within the GIT (ALVAREZ 1975).

The increase in reducing sugar contents in the caeca for the three extreme final molasses levels compared to the maize control are a consequence of the higher quantity of easily fermentable, soluble sugars in the final molasses. This, together with the greater rate of passage of the digesta for this type of diet (ALVAREZ 1975), will limit the capacity of utilization of these sugars in the SI, and thus, the quantity reaching the lower zones of the GIT will be greater. This increase in the quantity of reducing sugars in the caeca could induce a greater fermentative activity in these organs (ALVAREZ—LY 1975), which would dpend to a large extent on their microbial population and on the nature and quantity of the substrate reaching them (ANNISON *et al.* 1968). This excessive fermentation in the lower zones of the GIT could be responsible for the decrease in feed consumption by the birds and for the progressive fall in metabolisable energy (ME) of the rations as the final molasses level in the diets increases (ALVAREZ 1974).

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BIOMETRICAL STUDIES IN CAPSICUM (CAPSICUM ANNUUM L. VAR. GROSSUM SENDT.). I. HERITABILITY AND CORRELATIONS

Capsicum is an impotrant vegetable because of its mild pungency. The yield of this crop is very low in India compared to that obtained in European and American countries. A knowledge of heritability and correlations is an essential prerequisite in planning breeding programmes aimed at improving the yield.

In recent years very few workers have conducted studies on these aspects in *Capsicum* (JO—YU 1973, ARYA—SAINI 1976a, CHANG 1977). The present study provides information on these aspects under two different plant spacings.

The study was conducted during the late "rabi" season of 1977 at the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, India. Seventeen pure lines, including California Wonder, constituted the experimental material. The trials were laid out in randomised block designs with three replications in each design. The spacings adopted in the two experiments were 50 cm × 40 cm and 50 cm × 30 cm, respectively. Observations on ten randomly selected plants were recorded for total fruit yield, total fruit number, early fruit yield (first three pickings), early fruit number, plant height, plant spread, number of primary branches, number of secondary branches, days to first flowering, days to first fruit maturity,

Table 1

Estimates of heritability in a broad sense for different traits in capsicum

Traits	Heritability estimates under	
	Normal spacing	Closer spacing
1. Total fruit yield per plant	0.0000*	0.2738
2. Total fruit number	0.0903	0.3930
3. Early fruit yield per plant	0.0097	0.4004
4. Early fruit number	0.1820	0.5921
5. Plant height	0.5598	0.7170
6. Plant spread	0.0000*	0.4532
7. Number of primary branches	0.3609	0.3267
8. Number of secondary branches	0.3354	0.4201
9. Days to first flowering	0.2152	0.4309
10. Days to first fruit maturity	0.0076	0.1701
11. Fruit length	0.6928	0.5036
12. Fruit breadth	0.7850	0.6191
13. Fruit flesh thickness	0.4190	0.2571
14. Percentage dry matter content of fruits	0.3689	0.3802
15. Plant height up to first furcation	0.2858	0.1321

* Negative estimates made up to zero.

Table 2

Phenotypic (P) and genotypic (G) correlations between

	Total fruit yield	Total fruit number	Early fruit yield	Early fruit number	Plant height	Plant spread	Number of primary branches	Number of secondary branches	Days to first flowering
1.		0.65**	0.87**	0.53**	0.55**	0.64**	0.36**	0.58**	−0.29*
		—	—	—	—	—	—	—	—
2.			0.52**	0.74**	0.55**	0.47**	0.08	0.44**	−0.39**
			−5.32**	0.41	0.83**	—	0.42	0.14	0.28
3.				0.63**	0.53**	0.63**	0.25	0.50**	−0.32*
				3.40**	0.65**	—	0.94**	−1.40**	5.47**
4.					0.45**	0.40**	−0.12	0.16	−0.56**
					0.10	—	0.91**	−0.72**	−0.24
5.						0.71**	0.02	0.47**	−0.06
						—	0.09	0.43	0.50*
6.							0.23	0.55**	−0.01
							—	—	—
7.								0.48**	0.13
								0.46	0.78**
8.									0.01
									0.86**
9.									
10.									
11.									
12.									
13.									
14.									
15.									

*, ** Denote significance at 5% and 1%, respectively.

Note: Total fruit yield and plant spread had negative heritability estimates of −0.0503 and −0.0481 and hence their genotypic correlations with other traits were not computed.

fruit length, fruit breadth, fruit flesh thickness, dry matter content of fruits (%), height up to first furcation and dry matter content of leaves.

The analysis of variance for randomised block design was done as suggested by COCHRAN—COX (1959). The heritability (in a broad sense), as the ratio between genotypic variance, was estimated from the analysis of variance table. The genotypic and phenotypic correlations between all possible characters were computed according to the procedure suggested by AL-JIBOURI *et al.* (1958).

a) *Heritability*: In general, under both the spacings, traits such as fruit breadth, fruit length and plant height exhibited medium to high heritability estimates (Table 1), though early fruit number only had this sort of value under the closer spacing. This indicated that these traits respond well to selection. Similar estimates of heritability have been obtained by SINGH—SINGH (1977) in chilli and CHANG (1977) in sweet pepper.

The negative heritability estimates obtained for total fruit yield and plant spread under normal spacings could be due to the sampling variation around the true low values. SINGH—SINGH (1977) obtained a similar estimate of heritability for days to flowering in chilli.

b) *Correlations*: It can be seen from Tables 2 and 3 that genotypic correlations in many cases exceeded the maximum limit of unity. This is because the sampling variances of genotypic correlations become too large to be of use as a result of low heritability values and are seldom precise.

sixteen characters in capsicum under normal spacing

Days to first fruit maturity	Fruit length	Fruit breadth	Fruit flesh thickness	Dry matter content of fruits (%)	Height up to first furcation	Dry matter content of leaves	
−0.27*	0.03	0.32	0.10	−0.17	0.26	0.01	P
—	—	—	—	—	—	—	G
−0.39**	0.17	−0.16	−0.26	0.04	0.16	0.12	P
4.27**	0.65**	−1.23**	−1.65**	0.50*	0.18	1.44**	G
0.25	0.03	0.28*	0.27*	−0.13	0.20	−0.09	P
3.34**	−1.16**	0.17	1.01**	−1.08**	0.96**	4.34**	G
−0.41**	0.36**	−0.35**	−0.10	0.04	0.03	−0.14	P
3.76**	1.01**	−1.40**	−0.65**	0.30	−0.42	0.09	G
−0.18	0.08	0.12	−0.09	−0.05	0.36**	0.14	P
0.72**	0.02	−0.07	−0.49**	0.23	0.64**	0.83**	G
0.03	0.02	0.24	0.11	−0.19	0.13	0.08	P
—	—	—	—	—	—	—	G
0.14	−0.36**	0.49**	0.18	−0.04	0.16	−0.01	P
1.16**	−0.71**	0.57*	−0.19	0.04	0.14	−1.56**	G
0.08	−0.05	0.25	0.23	0.09	0.03	0.20	P
4.55**	−0.44	0.03	−0.04	0.67**	0.09	0.77*	G
0.73**	−0.40**	0.24	−0.08	−0.06	−0.07	0.23	P
0.66**	−0.90**	0.85**	0.47*	0.12	−0.25	0.40	G
	−0.10	−0.07	0.17	−0.05	−0.25	0.14	P
	−0.94**	0.21	5.03**	3.01**	−5.12**	0.14	G
		−0.55**	−0.03	−0.21	−0.21	−0.13	P
		−0.87**	−0.27	−0.27	0.50**	0.21	G
			−0.27*	−0.08	0.37**	−0.03	P
			0.08	−0.07	0.54*	−0.05	G
				−0.01	−0.18	0.10	P
				0.02	−0.65**	−0.11	G
					−0.04	−0.16	P
					−0.06	−0.90**	G
						−0.15	P
						0.66**	G

All the yield attributes studied, i.e. total fruit yield, total fruit number, early fruit yield and early fruit number, had significant positive correlations among themselves. This suggested that linear relationships exist between these traits and selecting any of these traits will naturally result in an improvement in total fruit yield. The positive correlation of number of fruits with fruit yield has been reported by RAO *et al.* (1974) in chilli and CHANG (1977) in sweet pepper.

Among the morphological traits, plant height, plant spread and number of secondary branches were positively correlated with fruit yield. This seems to be due to the production of more vegetative growth as a result of a larger canopy of the plant. The positive association of plant height and fruit yield has been observed by ARYA—SAINI (1976b), and RAO *et al.* (1974) in chillies.

The two physiological traits, i.e. days to flower and days to maturity, had a high positive correlation between them. The negative correlations of these traits with total fruit yield suggested that selecting early flowering and early maturing genotypes would lead to an increase in total fruit yield too. Similar results have been reported by JO—YU (1973) in sweet pepper and RAO *et al.* (1974) in chillies.

Among other fruit traits, the correlation between fruit length and fruit breadth was positive under closer spacing but was negative under normal spacing. Fruit breadth was positively correlated with total fruit yield. This is expected because of a direct increase in

Table 3

Phenotypic (P) and genotypic (G) correlations between

	Total fruit yield	Total fruit number	Early fruit yield	Early fruit number	Plant height	Plant spread	Number of primary branches	Number of secondary branches	Days to first flowering
1.		0.61**	0.79**	0.60**	0.54**	0.62**	0.26	0.49**	−0.23
		0.82**	0.76**	0.45	0.57*	0.56*	0.37	0.60*	0.50*
2.			0.37**	0.67**	0.50**	0.47**	0.16	0.41**	−0.36**
			0.30	0.98**	0.65**	0.61**	−0.01	−0.62**	−0.35
3.				0.59**	0.33*	0.43**	0.02	0.31*	−0.38**
				0.41	0.25	0.13	−0.13	0.31	0.19
4.					0.35*	0.34*	−0.11	0.29*	−0.63**
					0.29	0.11	−0.31	0.32	−0.73**
5.						0.80**	0.17	0.40**	0.01
						0.85**	0.17	0.52*	0.38
6.							0.21	0.47**	−0.02
							0.56*	0.98**	0.69**
7.								0.38**	0.18
								0.40	0.50*
8.									−0.02
									0.28
9.									
10.									
11.									
12.									
13.									
14.									
15.									

*, ** Denote significance at 5% and 1%, respectively.

fruit size. Jo—Yu (1973) also obtained a positive correlation of fruit width with fruit yield.

A comparison of Tables 2 and 3 revealed that the association between traits tended to be of higher magnitude under normal than under closer spacing. Rammah—Bőjtös (1976) also observed similar changes in correlations with changed planting systems.

It is concluded that the ideotype of capsicum should be early maturing and should have more height, spread and number of fruits per plant.

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Prepared at the Indian Institute of Horticultural Research, Bangalore

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sixteen characters in capsicum under closer spacing

Days to first fruit maturity	Fruit length	Fruit breadth	Fruit flesh thickness	Dry matter content of fruits (%)	Height up to first furcation	Dry matter content of leaves	
−0.34*	0.05	0.50**	0.30*	0.34*	0.09	0.15	P
0.32	−0.80**	0.38	0.63**	0.98**	0.29	0.58*	G
−0.39**	0.10	−0.08	−0.03	0.38**	0.10	0.07	P
−1.17**	−0.11	−0.42	0.12	0.59*	0.57*	0.55*	G
0.24	−0.09	0.37**	0.36**	0.37**	−0.06	−0.06	P
0.21	−0.44	0.38	0.77**	0.47	0.11	−0.26	G
0.57**	0.23	−0.22	0.08	0.23	0.08	−0.09	P
−1.10**	0.36	−0.55*	0.27	0.32	0.19	−0.25	G
−0.21	0.06	0.21	0.08	0.26	0.25	0.18	P
−0.08	−0.39	−0.04	−0.10	0.47	0.49*	0.34	G
−0.24	0.13	0.30*	0.17	0.34*	0.09	0.35*	P
0.37	−0.68**	0.03	0.09	0.49*	−0.18	0.45	G
0.28*	−0.09	0.19	−0.10	−0.07	−0.04	0.29*	P
0.54*	−0.51	0.38	0.49*	0.23	−0.77**	1.15**	G
0.04	−0.03	0.09	0.09	0.09	−0.20	0.20	P
−0.30	−0.38	0.13	0.57*	0.59*	−0.85**	0.87**	G
0.59**	−0.41**	0.26	0.04	0.01	−0.05	0.24	P
1.12**	−0.60*	0.99**	0.44	0.41	0.42	0.44	G
	−0.39**	0.13	−0.09	−0.07	−0.25	−0.08	P
	−0.37	1.37**	1.53**	−0.51*	0.03	0.35	G
		0.40**	0.21	−0.39**	0.02	−0.09	P
		−1.11**	−0.16	−0.82**	−0.64**	−0.20	G
			0.35*	0.24	0.11	−0.05	P
			0.14	0.54*	0.13	0.17	G
				−0.07	0.04	0.06	P
				−0.41	−0.58*	0.06	G
					0.04	0.11	P
					0.94**	−0.07	G
						−0.01	P
						−0.53*	G

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CERTAIN ANATOMICAL FEATURES OF JUTE LEAVES AND THEIR TAXONOMIC IMPORTANCE

The two species of *Corchorus* which yield commercial jute have received intensive attention both from the botanical and from the agricultural point of view. Regarding the plant itself, the anatomy of the stem, especially with reference to the origin, structure and distribution of the fibres, has been worked out in detail and has been amply described and illustrated in monographs and reviews (KUNDU 1942, 1943, 1956, 1959, METCALFE—CHALK 1950, PATEL—GHOSH 1944, RAO—KUNDU 1955, SARMA 1969, WEINDLING 1947). There are a few reports on the development, dimensions and frequency of the stomata (KUNDU—SEN 1958, SEN—PAUL 1961, MITRA—BASU 1974).

While studying a large collection of jute germplasms for screening their range of genetic variability with respect to various characters, it was found that some of the anatomical structures of jute leaves have somehow escaped critical study. These are the multicellular glands, unicellular hairs and mucilage cells which are present as a rule on both the surfaces

Table 1

Mean number of glands per microscopic field

Variety	Cotyledons		Adult leaves	
	Upper surface	Lower surface	Upper surface	Lower surface
C. capsularis				
D-154	57.6 ± 10.45	21.0 ± 7.78	15.3 ± 4.12	24.0 ± 4.17
C-321	52.5 ± 7.37	24.4 ± 10.13	13.6 ± 5.20	22.4 ± 4.05
C-7447	58.5 ± 15.83	30.9 ± 14.27	21.0 ± 7.55	36.2 ± 9.31
Maniksari	63.7 ± 15.86	34.2 ± 8.47	23.0 ± 6.24	34.9 ± 10.69
Tripura	33.7 ± 6.18	6.1 ± 3.30	14.1 ± 2.38	39.9 ± 7.16
Bangkok	82.9 ± 11.84	86.4 ± 6.66	8.5 ± 2.20	40.7 ± 3.66
Chinese	55.6 ± 11.43	19.4 ± 9.07	17.4 ± 2.91	49.8 ± 7.26
Taichung	55.6 ± 15.62	25.6 ± 6.95	16.8 ± 3.03	36.9 ± 2.84
EC 41337	61.0 ± 25.60	22.3 ± 6.71	12.2 ± 2.14	28.1 ± 3.27
EC 41338	11.2 ± 3.54	5.3 ± 1.45	9.6 ± 1.20	39.6 ± 3.88
Species mean	53.2	27.6	15.2	35.3
C. olitorius				
JRO-620	50.8 ± 8.87	6.3 ± 1.10	17.4 ± 2.87	15.5 ± 2.97
JRO-632	50.1 ± 9.43	15.0 ± 6.20	20.8 ± 3.68	16.6 ± 3.56
JRO-4630	39.8 ± 8.53	10.8 ± 4.53	15.3 ± 2.93	11.7 ± 2.87
JRO-4362	34.9 ± 7.98	9.5 ± 4.36	12.1 ± 4.04	8.6 ± 2.80
JRO-3690	25.8 ± 6.66	8.5 ± 2.66	9.5 ± 2.16	7.6 ± 2.37
WOD	40.0 ± 6.77	3.1 ± 0.94	36.2 ± 2.36	37.2 ± 2.76
WOG	24.0 ± 6.15	5.1 ± 2.81	12.3 ± 2.10	30.3 ± 3.47
WOR	36.9 ± 11.41	6.0 ± 3.44	19.5 ± 4.65	40.9 ± 4.74
Goa	35.3 ± 5.14	11.8 ± 3.87	35.9 ± 3.75	37.1 ± 6.33
Susunia	60.2 ± 15.03	14.5 ± 8.32	17.7 ± 2.37	43.1 ± 4.09
Species mean	39.4	9.1	19.7	24.9

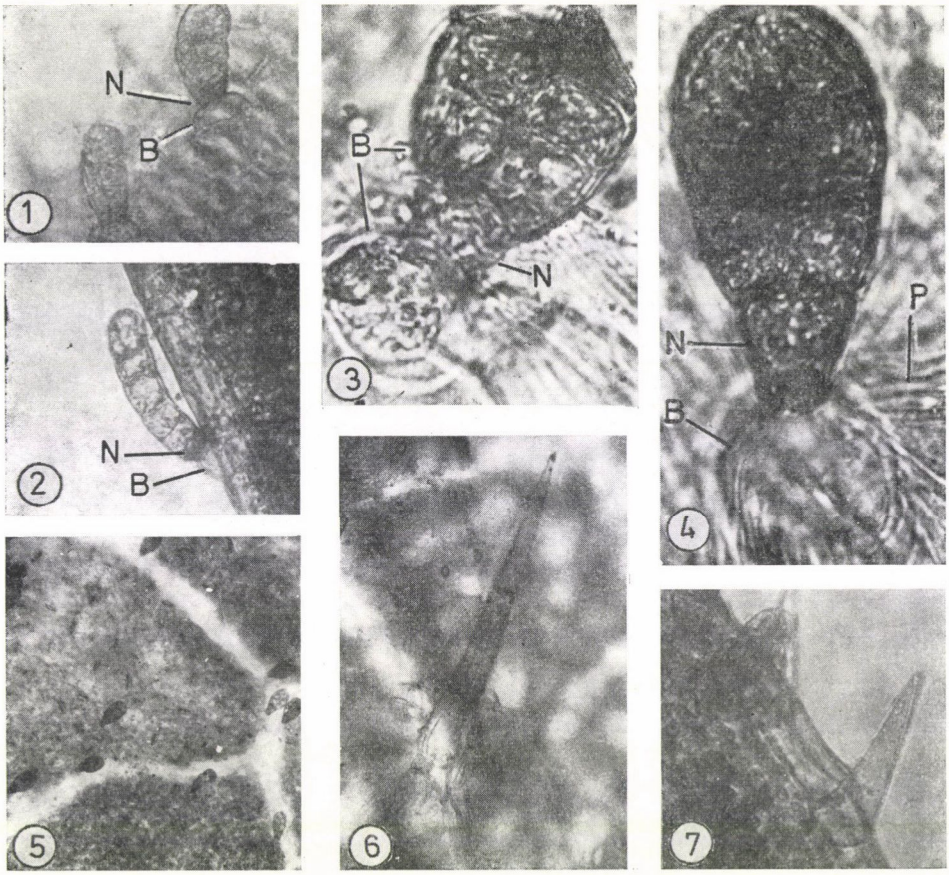
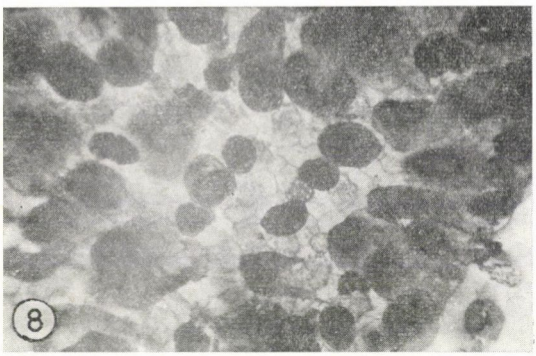


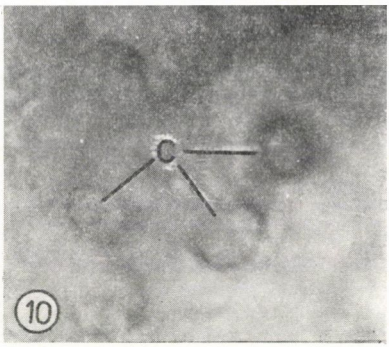
Fig. 1. Capsularis type cotyledonary gland ×400
Fig. 2. Olitorius type cotyledonary gland ×400
Fig. 3. Capsularis type leaf gland ×3000
Fig. 4. Olitorius type leaf gland ×3000
Fig. 5. Glands are distributed along the veins of an adult leaf ×400
Fig. 6. A hair on the vein of an adult leaf ×400
Fig. 7. A cotyledonary hair restricted to the margin ×400. N: neck cell; B: basal cell: P: cuticular pellicle

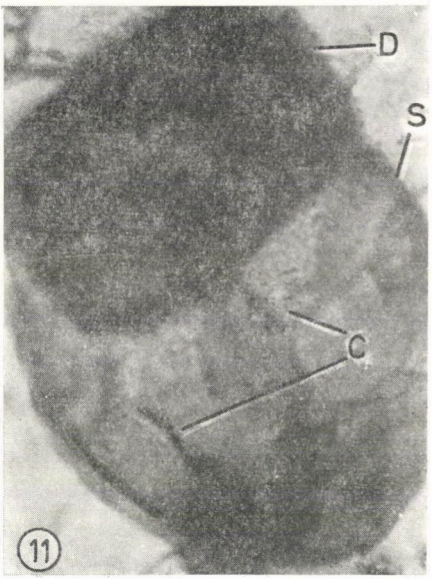
of the cotyledons and in adult leaves. It is not known whether these structures have any taxonomical value or if they play any part in the performance of the crop. From the available literature it also appears that the pattern of venation and the anatomy of the vein endings of this important crop have yet to be worked out. A detailed study was therefore conducted to deal with the above aspects.

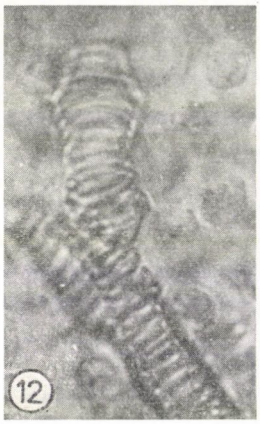
The materials selected for this investigation were five cultivated *capsularis* varieties (D-154, C-321, JRC-7447, Maniksari and Tripura); five wild *capsularis* varieties (Bangkok, Chinese, Taichung, EC-41337 and EC-41338); five cultivated *olitorius* varieties (JRO-620, JRO-632, JRO-4630, JRO-4362 and JRO-3690); and five wild olitorius varieties (W.O.D. W.O.G., W.O.R., Goa and Susunia).

To eliminate errors involved in making restricted observations, 10 random samples were collected from plants of each variety raised from appropriately designed randomized blocks. Observations (average of 15) were made on each sample, i.e. cotyledons and leaves,









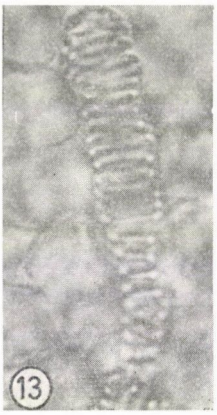


Fig. 8. Top-view of the darkly stained epidermal mucilage cell ×500

Fig. 9. The mucilage cells in a water mount; their expanded nature is clearly revealed by the protrusions ×500

Fig. 10. A mucilage cell — highly magnified top-view ×4000

Fig. 11. A mucilage cell — side view ×4000

Fig. 12. A *capsularis* type vein ending ×2000

Fig. 13. An *olitorius* type vein ending ×2000. D: apical disc; S: sub-epidermal sac; C: tubular canals

after removal of chlorophyll, followed by staining with Sudan Black or methylene blue solutions (2% alc.). To study the venation and vein endings of leaf materials, the leaf clearing procedure described by PEACOCK (1966) was followed.

Multicellular glands. The glands present in the cotyledons are 3—4-celled, uniseriate and club shaped, with their basal cup-like cell embedded below the epidermal surface (Figs 1—2). The basal cell is thin-walled, containing transparent sap and a prominent nucleus. The neck cell above it is protected by a dark cuticle like a pellicle all around. The glands are distributed mostly along the margins.

In the adult leaves, the uniseriate glands become globular (Figs 3—4) by following the usual quadrant and octant divisions of the apical cells. The characteristic features of the basal cell, neck cell and the cuticular pellicle remain unchanged. The epidermis is interrupted by these glands and hairs and is covered by a striated cuticular pellicle. Although the glands are found scattered throughout the leaf surface, they are largely distributed on the veins and veinlets (Fig. 5).

The rich cell content of the glands (both of cotyledons and leaves), although stained with Sudan Black solution, is not soluble in ether or alcohol and does not give a protein reac-

Table 2

Mean number of mucilage cells per microscopic field

Variety	Cotyledons		Adult leaves	
	Upper surface	Lower surface	Upper surface	Lower surface
C. capsularis				
D-154	6.5 ± 0.81	2.9 ± 0.94	15.3 ± 2.45	0.7 ± 0.78
C-321	7.2 ± 1.17	3.8 ± 1.33	12.4 ± 2.46	2.9 ± 1.58
C-7447	6.6 ± 1.28	3.2 ± 1.08	13.3 ± 2.76	1.5 ± 0.92
Maniksari	6.1 ± 0.83	5.1 ± 0.94	10.4 ± 2.24	1.0 ± 1.00
Tripura	5.4 ± 0.92	2.8 ± 0.87	13.5 ± 2.66	2.1 ± 1.30
Bangkok	6.8 ± 0.98	5.0 ± 1.41	12.7 ± 2.00	4.0 ± 1.48
Chinese	8.1 ± 1.45	4.7 ± 1.42	14.0 ± 1.95	3.7 ± 1.49
Taichung	7.0 ± 1.18	4.3 ± 1.62	12.6 ± 2.58	3.7 ± 1.42
EC 41337	5.1 ± 1.14	3.4 ± 1.28	8.6 ± 1.91	3.6 ± 1.50
EC 41338	4.6 ± 0.95	1.6 ± 0.87	15.1 ± 2.26	4.4 ± 1.56
Species mean	6.3	3.7	12.8	2.8
C. olitorius				
JRO-620	10.0 ± 2.14	5.8 ± 0.87	6.2 ± 1.25	3.6 ± 1.91
JRO-632	12.3 ± 3.41	7.1 ± 2.07	8.5 ± 1.86	5.3 ± 1.62
JRO-4630	10.6 ± 3.01	6.6 ± 1.62	8.2 ± 2.00	5.4 ± 1.50
JRO-4362	9.4 ± 1.96	5.2 ± 1.25	12.7 ± 2.92	8.6 ± 1.80
JRO-3690	11.1 ± 2.66	8.3 ± 1.95	14.3 ± 3.82	11.3 ± 2.19
WOD	9.4 ± 2.11	7.4 ± 1.96	13.1 ± 1.45	10.6 ± 2.94
WOG	6.4 ± 1.15	5.3 ± 0.85	14.2 ± 1.94	4.1 ± 1.70
WOR	8.7 ± 1.48	8.9 ± 1.68	18.2 ± 4.33	10.1 ± 2.51
GOA	8.5 ± 2.16	8.3 ± 2.51	16.6 ± 3.14	12.0 ± 2.97
Susunia	6.2 ± 1.25	5.5 ± 1.80	15.7 ± 2.79	10.4 ± 2.11
Species mean	9.3	6.8	12.8	8.1

tion. The frequency of distribution of the glands in *capsularis* jute is higher than that of the *olitorius* varieties (Table 1). The distribution per unit area is greater on the cotyledons than, on the adult leaves. In addition, the number on the upper surface is higher than that on the lower surface, and these glands are more globular and shorter in *capsularis* but longer and narrower in *olitorius* (Figs 1—4).

Hairs. There are two types of unicellular hairs. In the adult leaves, each hair has a prominent basal part situated at the level of the epidermis. Though scattered on the upper surface, they are restricted on the lower surface to the veins and veinlets only. They are long and stiff, their cell lumen being extremely narrowed due to heavy mineralization of their walls (Fig. 6). The cotyledonary hairs are much smaller and comparatively thin-walled, each having a conspicuous nucleus (Fig. 7). These are distributed on the margins only. Unlike the glands, their structure and distribution are uniform in both the species.

Mucilage cells. The presence of mucilage cells in members of Tiliaceae has been reported by earlier workers (KUNDU 1959, METCALFE—CHALK 1950). They are much more complex in their structure. The cell consists of an apical disc of epidermal origin (Fig. 11). Ther is a sub-epidermal mucilage sac situated just beneath it and it is provided with tubular canals (Fig. 11). In a magnified top view (Fig. 10), the open ends of these tubular canals are clearly visible. The epical disc is hard and gives a dense stain with methylene blue (Fig. 8). But the mucilage sac is delicate and thin-walled and hardly visible from the top-view. In adult leaves, these are often found convoluted, sometimes resembling multiple sacs. These sacs are very hygroscopic in nature, because in water mounts they continue to absorb water and expand to a considerable extent, a characteristic property of mucilage (Fig. 9). These mucilage cells are less frequent on the cotyledons than on the adult leaves (Table 2). In both cases, their numbers are greater on the upper surfaces. In general, the *olitorius* types had larger numbers of mucilage cells than the *capsularis* ones, both on the cotyledons and on adult leaves. More detailed work and experimental studies are in progress to understand their precise function. It may be mentioned that the entire internal cellular system of the jute plant remains permeated by a film of mucilage.

Venation and vein endings. There are three primary veins arising from the base of the leaves in both species and they remain free throughout. The termination pattern of the secondary veins is of the "comptodromous type". In *Corchorus olitorius*, the secondary veins terminate at the tooth margin forming complete loops, while in *C. capsularis*, the secondaries extend up to a certain extent beyond the loops. At the apices of the leaves, in both species, the secondary veins on either side fuse with the primary vein and form a spreading broom-like appearance. The tuft of veins which terminate at the leaf apices remain compact in *capsularis*, whereas in *olitorius* they are arranged loosely. There are more tertiaries per unit area of leaves in *olitorius* than in *capsularis*, but the number of vein endings (idioblasts) appears to be inversely related. This is because in the *olitorius* varieties, each idioblast is of a simple type, rarely forming more than one idioblast from each initial; but in the *capsularis* type, the endings are compound in nature, i.e. each initial always forms more than one idioblast, sometimes even up to 4—5. Thus, there exists a conspicuous difference between these two species in respect of the nature of their vein endings. In *C. capsularis*, the idioblasts consist of distinct trachiedal elements whose terminal ends expand, presenting a bulbous appearance with serrated margins (Fig. 12). In the case of *C. olitorius*, on the other hand, the terminal ends proliferate a little without having any serratures and resemble typical annular vessels (Fig. 13).

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GENOTYPE-ENVIRONMENT INTERACTIONS OF LEAF CHARACTERISTICS IN RICE ASSOCIATED WITH SOIL DIFFERENCES

The importance of the flag leaf for high yield in rice (*Oryza sativa* L.) has long been established. Genetic variation in leaf characters is very common. Any attempt to explain this variation must take account of possible genotype-environment interactions. If genotype-environment interaction is high in a metrical character, directional selection at the phenotypic level could give rise to fluctuating selection at the genotypic level. In this paper, an investigation on the effect of different soils on the expression of the leaf characters of the flag leaf and the leaf below the flag leaf in 13 rice lines has been described.

The materials included were 13 varieties of rice (*Oryza sativa* L.) of which six were locally developed, four were foreign varieties and three were local varieties, as follows:

a) Locally developed varieties (dwarf and semi-dwarf):
RU 1, RU 2, RU 3, RU 4, BR 3 and Chandina.
b) Foreign varieties (dwarf):
IR 532, IR 20, IR 8 and Chinese.
c) Local varieties (tall):
Naizersail, Kataribhog and Kalozira.

Seedlings of each variety were raised in eight 12″ pots containing eight combinations of the presence or absence of nitrogen (N), phosphorus (P) and potassium (K) during June 1976. They were transplanted into pots containing the same combinations of N, P and K fertilizer at the age of 20 days. For each combination there were four 12″ pots per variety. There were 416 pots altogether and they were arranged randomly in the open field under direct sunlight.

Fertilizers were used at the rate of 2 g urea (N), 2 g triple super phosphate (P) and 1 g muriate of potash (K) per combination. This amount was added to each pot three times, once at the time of transplantation, once at the time of tiller initiation and once at the time of flowering. The usual weeding and irrigation were done whenever necessary.

The characters studied were: 1. Flag leaf length (FlL), 2. Flag leaf breadth (FlB), 3. Flag leaf area (FlA), 4. Flag leaf angle (FlAn), 5. Leaf below flag leaf length (LBFlL 6. Leaf below flag leaf breadth (LBFlB), 7. Leaf below flag leaf area (LBFlA) and 8. Leaf below flag leaf angle (LBFlAn).

The data were analysed following techniques equivalent to those developed by FINLAY—WILKINSON (1963), EBERHARD—RUSSEL (1966), MATHER—JONES (1958), YATES—COCHRAN (1938) and PERKINS—JINKS (1968) to study G×E interaction in matrical traits.

A) Relative importance of different nutrients

The data were analysed by the usual analysis of variance and are presented in Tables 1 and 2. For all the eight traits, between genotypes (G), between environments (E) and G×E items were highly significant. The environments (E) sum of squares was then partitioned

Table 1

Mean performance of each genotype over the environments

	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
RU 1	21.38	34.25	1.27	1.03	35.54	47.41	31.94	18.12
RU 2	31.63	38.44	1.37	1.09	58.52	58.39	13.81	14.69
RU 3	24.44	39.94	1.22	1.10	44.13	59.28	29.25	17.38
RU 4	22.31	34.00	1.24	1.08	38.43	50.88	29.00	16.44
BR 3	24.75	32.75	1.18	0.96	39.65	42.88	12.19	17.44
Chandina	25.81	36.94	1.07	0.95	37.20	47.57	31.31	18.06
IR 532	27.69	35.56	1.33	1.08	49.72	52.13	16.25	14.62
IR 20	23.06	36.13	1.30	1.25	40.88	60.53	22.44	15.94
IR 8	20.75	26.88	1.08	0.92	31.80	33.98	27.31	19.44
Chinese	22.38	29.31	0.91	0.75	27.47	29.66	12.50	19.81
Naizersail	24.12	43.88	1.03	0.73	33.27	42.32	60.44	39.75
Kataribhog	26.81	41.48	0.86	0.63	31.60	34.17	45.63	21.06
Kalozira	27.75	42.75	0.86	0.51	31.99	29.09	67.75	23.63

Table 2

Mean squares of analysis of variance

Item	d.f.	FlL	LBFlL	FlB	LBFlB
Treatment (T)	7	257.31***	546.74***	0.374***	0.349***
Variety (V)	12	149.99***	404.35***	0.656***	0.743***
V×T	84	37.73*	49.20***	0.215***	0.044***
Regression	12	79.32***	29.00***	0.242***	0.821***
Deviation	72	26.13	52.68***	0.211***	0.046***
Error	312	26.35	12.68	0.076	0.006
		FlA	LBFlA	FlAn	LBFlAn
Treatment (T)	7	715.13***	193.47***	448.10***	635.48***
Variety (V)	12	4979.10***	680.94***	286.54***	486.78***
V×T	84	440.63***	135.05***	41.74***	57.18***
Regression	12	240.31***	102.17***	30.00***	49.14***
Deviation	72	474.02***	140.53***	43.69***	58.52***
Error	312	23.92	6.25	3.66	5.38

*, *** Significant at 5% and 0.1% level respectively.

Table 3

Mean effects of N, P, K and their combinations on different characters

	N	P	K	NP	NK	PK	NPK
FlL	41.38***	11.08*	4.92*	12.62*	0.31	— 3.23*	13.69*
LBFlL	62.54***	13.38*	10.69*	11.62*	— 5.15	11.46*	13.77*
FlB	1.64*	0.53*	0.16	0.01	— 0.44*	— 0.19	0.05
LBFlB	1.35*	0.13	— 0.33*	0.16	— 0.08	0.15	—0.29
FlA	57.31***	15.73*	5.33*	12.98*	—10.09*	— 4.36*	9.27*
LBFlA	70.37***	13.38*	1.87	14.24*	— 3.80	9.99*	4.83*
FlAn	72.08***	6.69	— 6.54	—2.08	— 3.37	—29.00*	—2.85
LBFlAn	36.31***	3.69	—11.46*	—7.23	11.38*	— 2.92	3.23

*, *** Significant at 5% and 0.1% level respectively.

into items measuring the effect of N, P, K and all possible interactions. These are given in Table 3. For example, the main effect of N for a given character is the mean performance of plants receiving N, less the mean performance of those not receiveing N. The N × P is the mean performance of plants receiving both N and P, less the mean of those receiving N but not P, less the mean of those receiving P but not N, plus the mean of those receiving neither N nor P. Most of the effects tabulated were significant at least at the 5% level.

Considering all nutrients separately, it is evident from the results (Table 3) that N had the largest single effect on the expression of these traits. P and K also had a significant effect on most of the traits, but these were much smaller than the N effect. With few exceptions, all the three nutrients when present increased the performance of these traits. Among the interaction effects, N × P and P × K are much more important. It is evident from these results that there is a wide range of environments giving ample opportunity for the manifestation of genotype-environment interactions if present.

As the G × E m.s. was significant, the N, P and K effects on the individual genotype were tabulated, as shown in Table 4. The effects were different on different genotypes but followed the same general pattern as shown in Table 2.

B) Variability

The estimates of variance components along with heritability, coefficient of variability, genetic advance and genetic advance over population mean are shown in Table 5. Genetic variation was greater than δ^2_{ge} and δ^2_e in most of these characters. These exceptions were in FlA and LBFlAn for δ^2_g and in FlL and FlB for δ^2_e. The highest genotype coefficients of variability for δ^2_g and δ^2_{ge} were shown by FlAn, followed by LBFlAn, whereas the lowest estimate of these was for FlL. Uncontrolled variation was highest in FlL, FlB, FlAn and LBFlAn compared to other characters. Heritability ranged from 0.19 for FlL to 0.65 for LBFlB. The low estimates of heritability for FlL and LBFlAn were due to high estimates of δ^2_e and δ^2_{ge} respectively. The highest genetic advance was expected for FlAn and the lowest for FlL and LBFlAn. High genetic gain and high heritability for the characters FlAn, LBFlB, LBFlAn and FlB indicate the importance of additive gene effects in these characters, and selection will be fruitful in improving these characters. The remaining characters were conditioned by non-additive gene effects. KHALEQUE *et al.* (1977a, b), KHALEQUE (1975) and KHALEQUE *et al.* (1978) reported similar information in rice.

C) Genotype-environment interaction

In the first step of analysis, possible pairwise combinations of environments were taken and for every such pair a calculation was done for the correlation coefficient between genotype performances by the usual product moment correlations method. The results are

Table 4

Effects of N, P and K (1st, 2nd and 3rd value of a group of three respectively) on the eight characters of different genotypes

	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
RU 1	−14	46**	2.3*	1.2***	14.4*	56.5***	179***	70***
	−28	−14	0.5	0.2	−23.8**	− 5.6	23	4
	− 6	−14	0.7	1.0**	10.7	10.4	65**	44***
RU 2	98***	79***	2.1	3.5***	139***	142***	59**	37***
	18	11	0.5	−0.7*	29.8***	− 8.6	− 3	21***
	8	43**	0.9	0.1	20.7**	24.3**	− 23	− 17
RU 3	45*	63***	2.3*	2.4***	77.1***	110***	26	94***
	29	16	0.3	0.6*	32.5***	40.5***	24	− 26**
	35	65***	0.5	−2.0***	37.4***	− 2.6	− 5.2***	− 22*
RU 4	45*	96***	2.4*	3.1***	69.2***	14.1***	134***	− 51***
	5	40**	0.6	0.5	7.9	40.1***	− 26	− 47***
	−25	−14	0.0	−0.3	−30.9***	−24.4**	− 50*	
IR 532	52*	74***	2.9**	2.6***	87***	102***	− 7	− 89***
	2	8	1.1	1.6***	25.7***	40.5***	17	− 67***
	− 4	34*	0.1	−0.2	2.6	23.7*	− 15	− 41***
BR 3	27	69***	1.5	1.4***	43.4***	77.9***	99***	15
	3	29*	0.3	0.0	5.2	23.1*	103***	5
	−51*	−41**	−0.3	−0.2	−41.8***	−28.2**	79***	− 35***
IR 20	43*	53***	1.8	2.0**	73.9***	88.3***	54.0**	54***
	27	41**	1.2	0.6**	44.1***	45.4***	− 22	6
	17	9	1.2	1.6***	34.2***	46.9***	30	− 10
IR 8	41*	46***	2.5*	0.2	76.9***	51.2***	37	19
	49*	42**	0.8	−1.6***	59***	− 2.4	25	− 5
	27	26	0.4	−2.4***	33.6***	−34.8***	− 1	− 19
Chinese	52*	60***	2.4*	1.5***	59.2***	64.5***	33	77***
	−24	−28*	1.2	0.7*	−11.2	− 4.9	35	7
	28	18	−0.4	−1.1***	2.1	− 9.5	− 33	11

Chandina	74***	81***	0.9	0.4	58.3***	49.2***	68***	99***
	− 2	5	0.7	0.6*	9.3	14.3	− 26	− 31**
	6	−17	−0.3	−0.2	− 1.5	−13.7	− 38	21*
Naizersail	34	64***	0.1	−0.3	27.7***	22*	−233***	−144***
	18	46**	−0.3	−0.7*	6.1	1.2	129***	80***
	36	48***	−0.11	−0.7*	22.9**	3.1	− 79***	−178***
Kataribhog	17	8	−0.1	−0.6*	1.9	−16.1	156***	− 15
	23	−46**	0.3	−0.3	114	−26.6*	−126***	7
	5	−50***	−0.3	0.2	−10.1	10.2	168***	79***
Kalozira	24	64***	0.1	0.1	15.9*	24.3***	332***	26**
	24	24	−0.3	0.1	8.4	10.9	− 66***	40***
	−12	32*	−0.3	−0.2	−13.4	19.0*	22	64***

*, **, *** Significant at 5%, 1% and 0.1% level respectively.

Table 5

Mean, standard error (S.E.), phenotypic (δ^2_p), genotypic (δ^2_g), environmental (δ^2_e) variances, coefficient of variability, heritability, and genetic advance (Gs) of different characters

	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
Mean	24.84	36.32	1.14	0.93	38.48	45.25	30.76	19.72
S.E.	0.50	0.35	0.03	0.01	0.19	0.23	0.47	0.25
δ^2_p	37.30	53.12	0.08	0.07	40.38	58.18	515.93	104.76
δ^2_g	7.26	22.19	0.04	0.05	17.68	26.85	283.85	34.19
δ^2_{ge}	3.69	18.26	— 0.03	0.12	19.04	25.95	208.35	64.40
δ^2_e	26.35	12.68	0.08	0.01	3.66	5.38	23.92	6.25
$CV\delta^2_g$	10.84	12.96	16.83	23.30	10.92	11.45	54.77	29.61
$CV\delta^2_{ge}$	7.73	11.76	—15.45	14.96	11.32	11.24	46.94	40.69
$CV\delta^2_e$	20.66	9.80	24.38	8.41	4.97	5.12	15.50	12.67
Heritability	0.19	0.42	0.44	0.65	0.44	0.46	0.55	0.33
Gs	2.45	6.27	0.26	0.36	5.73	4.77	25.72	6.87
Gs as % of mean	9.86	17.27	22.89	38.24	14.89	10.55	83.63	34.81

Table 6

Summary of results of correlation analysis between different environments
(Number of correlation coefficients within range is shown)

r range	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
0.00—0.20	7	2	1	0	6	2	1	9
0.21—0.40	9	6	0	3	8	3	5	7
0.41—0.60	8	13	8	7	8	10	8	5
0.61—0.80	4	7	12	12	3	12	8	5
0.81—1.00	0	0	7	6	3	1	6	2

summarized in Table 6. It is evident that for FlB and LBFlB the correlations were generally high, indicating good reproducibility of performance over environments and indicative of lower environmental effects on these genotypes. LBFlAn and FlAn also showed high correlation coefficients between a number of pairs of environments. For FlL, LBFlL and LBFlAn all the seven correlations between one environment lacking P and K but supplied with N and all other environments were between 0.0 to 0.4. For LBFlAn and FlAn the correlations were low between one environment with none of these nutrient ($N^-P^-K^-$) and P respectively. For FlAn the correlations were irregular with no clear pattern emerging. Therefore, the environments give rise to anomalous results and are identified by these correlations in most of these traits.

The next step is the regression analysis of variance, equivalent to that developed by YATES—COCHRAN (1938), FINLAY—WILKINSON (1963) and PERKINS—JINKS (1968). These results are summarized in Table 7. The values of the proportion of variation in the line mean accounted for by the regression were also determined [r^2 = regression s.s./(regressions.s. + remainder s.s.) as a percentage] and are presented in Table 7. High r^2 values for LBFlL,

Table 7

Summary of results of regression analysis and r^2 values as a percentage

	Range of r^2 values (%)			Number of significant	
	80—100%	40—80%	0—40%	regression m.s.	remainder m.s.
FlL	8	3	2	5	0
LBFlL	10	2	1	12	4
FlB	7	5	1	6	0
LBFlB	6	4	3	10	7
FlA	8	3	2	10	8
LBFlA	12	1	0	13	12
FlAn	4	7	2	12	12
LBFlAn	5	6	2	11	10

Table 8

*Regression coefficient (b) and S_b values of different genotypes**

	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
RU 1	−0.18	−0.80	1.22	0.67	0.28	0.80	1.55	1.23
	0.57	0.46	0.46	0.41	0.46	0.33	1.14	0.79
RU 2	2.13	1.09	1.33	2.33	2.24	1.69	0.64	0.85
	0.34	0.37	0.65	0.65	0.46	0.53	0.30	0.48
RU 3	1.29	1.24	1.22	2.17	1.53	1.75	0.36	2.13
	0.45	0.42	0.37	0.49	0.35	0.29	0.49	0.58
RU 4	0.80	1.43	1.44	2.33	1.07	1.89	1.70	1.54
	0.41	0.34	0.34	0.30	0.26	0.37	0.44	0.63
IR 532	1.37	1.24	1.77	2.17	1.59	1.46	0.01	2.26
	0.58	0.28	0.46	0.52	0.31	0.24	0.20	0.92
BR 3	0.25	0.95	0.55	1.00	0.57	1.09	1.15	0.29
	0.56	0.36	0.47	0.23	0.37	0.22	0.76	0.57
IR 20	1.20	0.96	1.22	1.17	1.38	1.38	0.49	1.19
	0.42	0.26	0.38	0.66	0.36	0.36	0.38	0.29
IR 8	1.40	1.31	1.44	0.67	1.52	0.95	0.34	0.53
	0.60	0.43	0.34	1.15	0.48	0.60	0.31	0.27
Chinese	0.84	0.89	1.11	1.50	0.77	0.94	0.85	1.44
	0.46	0.34	0.55	0.73	0.37	0.38	0.62	0.71
Chandina	1.44	1.00	0.44	0.33	0.93	0.64	0.75	2.35
	0.28	0.41	0.24	0.25	0.10	0.19	0.36	0.69
Naizersail	0.97	0.96	−0.22	0.07	0.49	0.26	−1.50	−1.33
	0.37	0.59	0.17	0.49	0.26	0.21	1.77	2.50
Kataribhog	0.76	0.03	−0.22	−0.67	0.23	−0.26	2.21	−1.27
	0.36	0.55	0.44	0.41	0.31	0.16	1.61	1.21
Kalozira	0.68	1.04	−0.22	0.002	0.38	0.38	4.41	1.58
	0.39	0.28	0.21	0.167	0.27	0.14	1.82	1.72

* 1st and 2nd values of pair correspond to *b* and S_b respectively.

LBFlA were unusual in these genotypes of diverse origin, but this means that though their performance changed differentially with the environment, the effect of the environments on the genes determining these characters is essentially similar. The results listed in Tables 6 and 7 also indicate that linear response to the environment is more important for FlL, LBFlL and FlB, whereas for the rest of the characters linear response to different environments as well as gene instability with an environment is equally important. JOARDER *et al.* (1978) and KHALEQUE (1975) also reported linear and non-linear types of G×E interaction in matrical characters in rice.

Considering the 13 genotypes individually, the linear regression *(b)* of genotype performances against the corresponding overall environmental means were calculated (Table 8).

Table 9

Values of stability ($\bar{S}^2_d$) of different genotypes

	FlL	LBFlL	FlB	LBFlB	FlA	LBFlA	FlAn	LBFlAn
RU 1	3.98	17.08	0.06	0.004	97.40	71.96	228.15	25.94
RU 2	18.43	7.76	0.04	0.12	97.76	188.78	5.83	5.89
RU 3	12.39	14.22	0.06	0.008	57.79	52.77	23.32	11.48
RU 4	14.53	4.50	0.06	0.001	59.07	90.35	13.60	0.94
IR 532	2.90	0.97	0.06	0.01	43.64	32.32	16.14	83.87
BR 3	4.05	7.17	0.06	0.002	62.67	29.65	88.16	10.70
IR 20	14.25	2.69	0.06	0.020	58.83	86.48	4.20	1.61
IR 8	1.18	15.37	0.07	0.070	106.49	245.72	5.03	2.30
Chinese	11.59	5.14	0.05	0.23	62.41	93.68	50.13	2.57
Chandina	21.02	12.33	0.07	0.002	1.43	21.72	1.50	18.74
Naizersail	16.66	39.60	0.07	0.008	30.30	25.81	581.49	321.26
Kataribhog	17.00	32.93	0.06	0.004	40.60	14.20	477.67	69.41
Kalozira	15.47	0.82	0.07	0.004	32.43	7.40	609.39	148.08

Table 10

Results of correlation studies within a character

	Correlation between		
	Mean and *b*	Mean and $\bar{S}^2_d$	*b* and $\bar{S}^2_d$
FlL	0.44	−0.34	0.36
LBFlL	−0.22	0.56*	−0.48
FlB	0.84***	0.42	0.45
LBFlB	0.69**	0.66*	0.07
FlA	0.81***	0.60*	0.38
LBFlA	0.68*	0.69**	0.41
FlAn	0.39	0.94***	0.35
LBFlAn	−0.56*	0.95***	−0.51

*, **, *** Significant at 5%, 1% and 0.1% level respectively.

Table 11

Correlation between b (upper right) and between means (lower left) among characters including yield/plant (YP)

	FlL	LBFlL	FlB	LBFlB
FlL		0.34	0.28	0.39
LBFlL	0.56*		0.60*	0.68*
FlB	0.08	−0.14		0.83***
LBFlB	0.13	−0.33	0.92***	
FlA	0.63*	0.15	0.81***	0.65*
LBFlA	0.19	0.15	0.92***	0.90***
FlAn	0.06	0.69**	−0.57*	−0.69**
LBFlAn	−0.12	0.48	−0.51	−0.57*
YP	−0.12	0.22	0.69**	0.67*

	FlA	LBFlA	FlAn	LBFlAn	YP
FlL	0.83***	0.36	−0.38	0.19	0.19
LBFlL	0.58*	0.75**	−0.24	0.60*	0.51
FlB	0.71**	0.84***	−0.31	0.58*	0.59*
LBFlB	0.75**	0.96***	−0.28	0.58*	0.47
FlA		0.74**	−0.41	0.40	0.37
LBFlA	0.81***		−0.24	0.61*	0.51
FlAn	−0.46	−0.42		0.16	−0.24
LBFlAn	−0.47	−0.41	0.72**		0.36
YP	0.42	0.81***	−0.17	−0.27	

*, **, *** Significant at 5%, 1% and 0.1% level respectively.

As the distributions of these 13b values were heterogeneous, as revealed by joint regression analysis (Table 2), these genotypes have different environmental responses. The standard errors of these 13b values were heterogeneous (Bartlett's X^2 test is shown in Table 8), as distinct differences exist between genotypes in the amount of deviation around the regression slope. The stability parameters, $\bar{S}^2_d$ (EBERHART—RUSSEL 1966) were calculated (Table 9); these measure the unpredictable irregularities in the response to the environment, which is different (joint regression analysis of Table 2) in different genotypes in these characters.

The correlation matrix of mean ($\bar{x}$), response (b) and stability ($\bar{S}^2_d$) is shown in Table 10. Mean performances were highly correlated with b and $\bar{S}^2_d$ in many of these characters, but those for b and $\bar{S}^2_d$ were not significant in any character, indicative of different gene control of b and $\bar{S}^2_d$. JOARDER *et al.* (1978) and KHALEQUE (1975) reported that stability and response are controlled by different gene systems in rice.

Correlation matrices of b and $\bar{x}$ between different leaf characters as well as yield/plant (YP) are shown in Table 11. Significant correlations between the mean performance of FlB, LBFlB and LBFlAn with YP were found to exist. These characters also showed significant correlations with most of the leaf characters.

Only FlB showed significant correlations with YP in respect to response (*b*), while LBFlL, FlB, LBFlB, FlAn and LBFlAn showed significant correlations among themselves and also with some other leaf characters. FlAn showed no correlations with any of the leaf characters.

*

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GROWTH AND NITROGEN, PHOSPHORUS AND POTASSIUM UPTAKE BY TRITICALE AND RYE

Studies on various aspects of nutrient accumulation by corn (*Zea mays* L.) have received considerable attention in the literature. Terman and his associates (Terman—Allen 1974, Terman—Noggle 1973, Terman *et al.* 1972) discussed several facets of nutrient accumulation and concentration change and relationships in both field and greenhouse-grown corn. Several workers (Jungk—Barber 1974, Mengel—Barber 1974, Warncke—Barber 1973, 1974) working with corn emphasized the measurement of nutrient uptake rates and other uptake parameters in relation to the plant root system. However, in comparison with corn, relatively little information is available in the literature on nutrient accumulation and rates of uptake by most of the small grain crops; the few available reports were concerned almost exclusively with wheat (*Triticum* sp.). The supply and uptake of P by spring wheat grown in a nutrient culture were studied by Boatwright—Viets (1966). Some aspects of accumulation and utilization of P and N by field-grown spring wheat were discussed by Kartseva (1967). Kudrev—Pandev (1967) observed a decrease in N uptake as a consequence of the decrease in total leaf surface of gravel-culture-grown wheat. In addition, there are few studies which have dealt with aspects of nutrient accumulation by other small grain crops. Power *et al.* (1970) discussed the effect of soil temperature on the rate of barley (*Hordeum* sp.) development and its nutrition. Rumburg—Sneva (1970) reported on the accumulation and loss of N in cereal rye (*Secale* sp.), while Hansen (1972) studied the relationship between chemical composition and form of isolated soil solution and the absorption of K, Na, Cu, Mg and added N by barley.

An understanding of growth pattern and nutrient accumulation, distribution, and rates of uptake during plant growth is an important step in developing adequate fertility programmes. *Triticale* (×*Triticosecale*, Wittmack), a man-made cross between rye (*Secale cereale* L.) and wheat (*Triticum aestivum* L.), has been promoted as a small grain crop (ZILLINSKY—BORLAUG 1971); virtually no studies have been published on its nutrient accumulation and uptake.

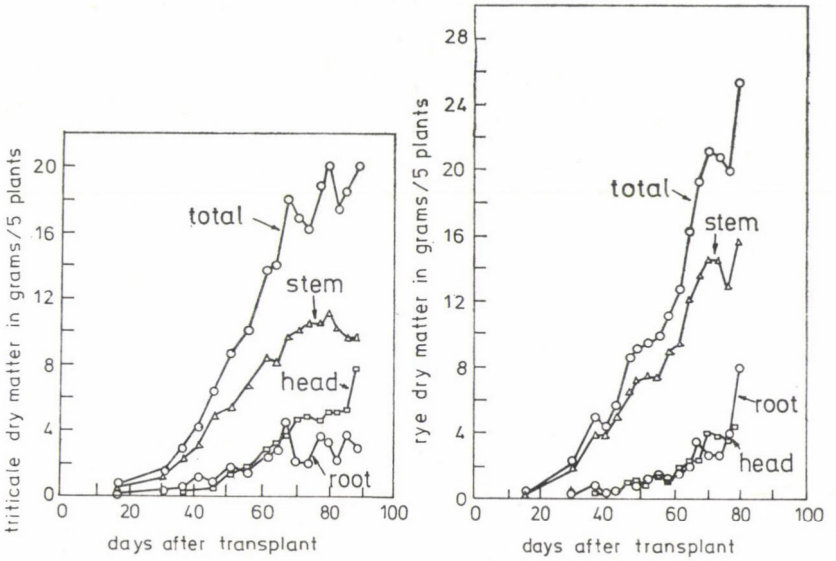

Fig. 1. Dry matter yield of roots, stems, heads and the whole plant for triticale and rye throughout their growth season under greenhouse conditions

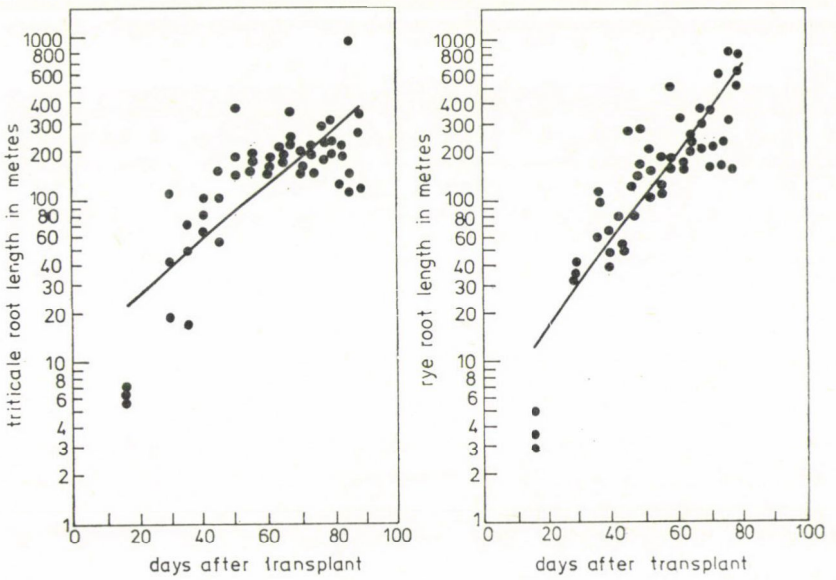

Fig. 2. The relation between log of root length (L) and time (t) for triticale and rye grown under greenhouse conditions

The objectives of the research in the present report were: i) to determine growth rates and the accumulation and the distribution of N, P and K in the roots, stems and heads of triticale, rye and wheat, ii) to determine the rate of N, P and K uptake per unit length of plant root and their rate of utilization per gram of dry matter.

A pot experiment was conducted in a greenhouse equipped with evaporative cooling devices to eliminate the need for shading during summer months. Temperatures usually ranged from 22 to 35°C depending on the season and the outside temperatures. Supplemental lights were provided during early growth in the winter months.

Locally obtained Hartsells sandy loam soil was used in the experiment. The soil had a pH of 5.4, CEC of 8.0 meq/100 g, 3.3% total organic matter, 0.16% total N, and 6.3 ppm soluble P in Bray P-1 soil extract. A saturation extract of the soil contained 4.48, 2.92 and 0.38 ppm of K, Ca and Mg, respectively. The soil was air dried and screened before a 5 kg sample was placed in each pot.

Hexaploid triticale 6TA 204 and locally grown Vitagraze rye and hexaploid Coker 68-15 wheat were used in this study. Seeds from the three cultivars were germinated separately for five days in a 1 : 1 sand-vermiculite mixture, after which they were put into vernalization at 2°C for 30 days. Following vernalization, and prior to transplant, the seedlings were left for three days to allow them to reach equilibrium with the environment. The seedlings were transplanted on February 16th 1974.

Nutrients were added in solution to each pot at the rate of 150, 100, 80 and 5 ppm of N, P, K and Fe, respectively, on an air dry basis. Pots were watered to about 25% moisture. With the first watering, 2 g of $Ca(OH)_2$ were added to each pot. Soil moisture was maintained approximately uniform by bringing the pots to a constant weight every two days and then daily as the plants advanced to maturity. Evaporation was minimized by placing a thin layer of black polyethylene over the soil surface. Evaporation losses were estimated by including pots without plants.

Seedlings were thinned to 5 plants/pot 14 days after transplant. Seventeen sequential harvests were made from separate sets of pots throughout the growth season; 3 pots of each cultivar were harvested at each harvest date. Upon harvest the plants were separated into stems (including leaves) and roots. After head initiation, the aerial parts were separated into stems and heads. Roots were recovered by washing them free of soil on two screens with tap water; the top and bottom sieves being of 16 and 40 mesh, respectively. Root fresh weights and root length were obtained prior to oven-drying. Root length was measured at each harvest using the procedure of NEWMAN (1966). Dry matter yields were determined after oven-drying the plant samples at 75°C. Nitrogen, P and K were also determined. Nitrogen was determined using the micro-Kjeldahl method, P was determined colorimetrically using the molybdenum blue method of Fish and Subbarow as described by BLACK (1965) and K by flame photometry.

Calculations were made for nutrient uptake and utilization (assimilation) rates using Williams' equation (WILLIAMS 1946, 1948) written as:

$$I = \frac{U_2 - U_1}{t_2 - t_1} \qquad \frac{\ln L_2/L_1}{L_2 - L_1} \tag{1}$$

$$\bar{I} = \frac{U_2 - U_1}{t_2 - t_1} \qquad \frac{\ln DM_2/DM_1}{DM_2 - DM_1} \tag{2}$$

where I is the mean uptake rate of a nutrient in mg m^{-1} day^{-1}, $\bar{I}$ is the mean utilization (assimilation) rate of a nutrient in mg g^{-1} day^{-1}, U is the nutrient content of the plant in milligrams, L is the root length in metres, DM is the dry matter of the plant in grams, and the subscripts 1 and 2 refer to measurements made at time t_1 and t_2 in days. These equations assume (i) that L and U (in the case of equation 1), and DM and U (in the case of equation 2) are linearly related and (ii) that L, DM and U are not discontinuous functions of time.

Although the following data specifically apply to the varieties tested, they may be cautiously used to indicate probable trends within each plant species.

Dry Matter and Root Growth. Accumulation of dry matter by the whole plant was continuous up to physiological maturity (89 days for triticale and 79 days for rye) (Fig. 1). However, with the exception of the last harvest, dry matter accumulation of triticale and rye tended to slow down around 64 days after transplant. This decrease in growth rate was much less pronounced in wheat, which continued to accumulate dry matter almost linearly up to the last harvest. This trend in the wheat cultivar may have been due to the absence of head formation and a continuation of vegetative growth throughout the season, a result of inadequate vernalization. Because of the lack of heading, the wheat data cannot be compared with those of triticale and rye.

Total dry matter yield and its distribution among plant parts (roots, stems and heads) varied between the two species. The contribution of different plant parts to total dry matter yield, at physiological maturity, was 15% from roots, 47% from stems (including leaves) and 38% from heads of triticale and 28%, 56% and 16%, respectively, in the case of rye. The contribution of the different plant parts to the total dry matter yield at different stages of growth could be easily calculated from the results shown in Fig. 1.

The length of roots increased exponentially with time for the two species as shown in Fig. 2. Regression analysis of the relation between root length in metres (L) and time after transplant in days (t) gave the following relationships:

$$\ln L = 2.472 + 0.039t \quad (r^2 = 0.63) \text{ for triticale}$$

$$\ln L = 1.505 + 0.062t \quad (r^2 = 0.77) \text{ for rye.}$$

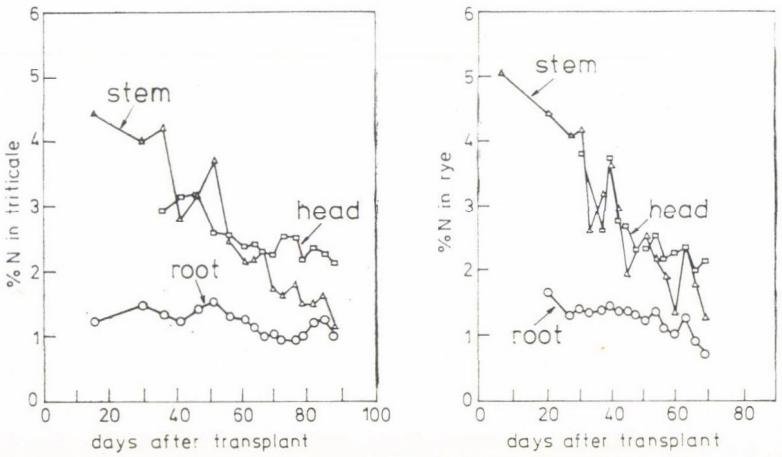

Fig. 3. Nitrogen concentrations in different parts of the plant during the growth season

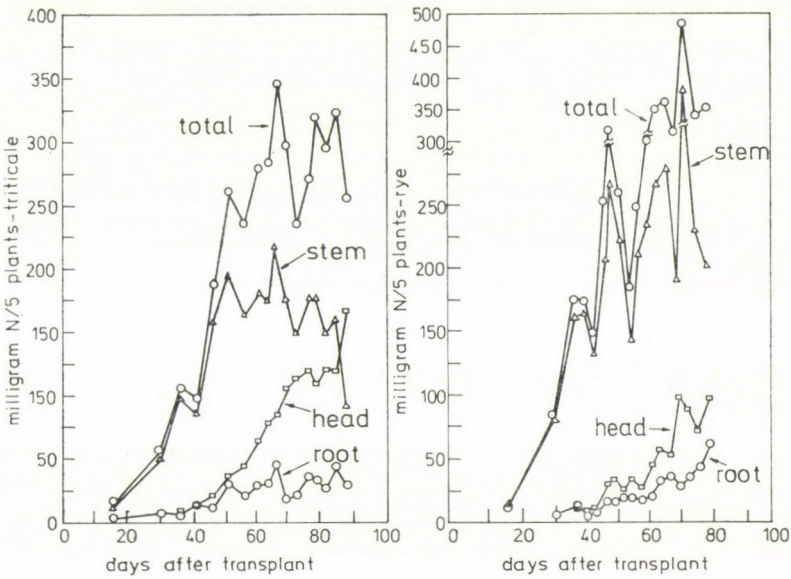

Fig. 4. Total uptake of nitrogen and its distribution among various plant parts during the growth season

Unlike rye, the growth rate of triticale roots tended to slow down, as indicated by their length, toward the end of the growth season. The slope of dry matter accumulation in the roots of triticale and rye did not correspond to the exponential growth of root length; this suggests that most of the new roots formed were of the fine type and root hairs.

Nutrient Concentration and Total Uptake

All data points shown for nutrient concentration and total uptake represent averages obtained from three pots at each harvest.

Nitrogen. Concentrations of N in triticale roots and stems at 16 days and heads at 40 days after transplant were 1.2, 4.4 and 3.1%, which decreased to 1.0, 1.1 and 2.1%, respectively, at the end of the 89 day growth season (Fig. 3). For rye, concentrations of N in roots, stems and heads decreased from 1.6%, 5% and 3.2% to 0.8%, 1.3% and 2.1%, respectively, at the end of its 79 day growth season.

The decrease or dilution of N in the plant tissue reflects the differential rates of growth and nutrient uptake by the plant when the rate of growth greatly exceeded the rate of nutrient uptake. High nutrient concentrations usually occur in the very young plants as a result of a relatively more rapid rate of uptake than of growth. However, with age, growth and dry matter build-up occur at a relatively much higher rate than that of nutrient uptake, thus leading to the dilution and decrease of N concentration. The dilution of N in the heads of both triticale and rye was much less pronounced than in the stems, which suggests N translocation from the stems to the heads. These findings are in agreement with the studies of Terman and his associates (Terman—Allen 1974, Terman—Noggle 1973, Terman *et al.* 1972), who reported and discussed the dilution/translocation in the corn plant. Roots had the lowest concentration of N among the plant parts; the continuous process of forming new roots accounted for the gradual slight decrease in N concentration.

The nitrogen content in various parts of the plant was calculated using N concentration in the particular plant part and its dry matter yield. Total N uptake by the whole plant was calculated by summing up the N content of various plant parts at each harvest date. Total uptake by the plants increased during the growth season and followed a pattern resembling that of a growth curve (Fig. 4). Total N uptake by triticale was about 2/3 that of rye. The distribution of N in various plant parts varied between species. At the last harvest, roots, stems and heads made up 10%, 32% and 58%, respectively, of the total N yield in triticale, and 17%, 57% and 26%, respectively, in the case of rye. The low proportion of total N content found in triticale and rye roots is comparable to the 16% value found by Warncke—Barber (1974) in corn roots, which also did not change very much with plant age.

While rye had accumulated more N (358 mg) in its tissues than triticale (286 mg) at the last harvest date, triticale heads had more N than those of rye; heads in triticale accounted for most of the N in the plant (166 mg), while rye heads had only 26% (93 mg) of the N yield, leaving the balance for the stems and roots. Apparently, triticale translocated more N from other aerial parts to heads than rye. The N content of triticale heads increased consistently throughout the seasons while the stems started to decrease 70 days after transplant, indicating some N translocation was taking place.

Phosphorus. Random samples of roots at different ages were analysed for P and were found to have less than 10 ppm P, a very low amount which suggested the loss of P during the washing process used in recovering the roots. The concentrations and content of P in different parts of the plants showed noticeable fluctuation; however, definite trends could be observed. In triticale, P concentrations in the stems increased from 0.09% at 16 days after transplant to 0.28% at 40 days, then decreased sharply to 0.05% at the end of the season (Fig. 5). The accumulation pattern reflected the differential rates of growth and P uptake. The increase in P concentration with plant maturity indicated a much more rapid rate of P uptake than that of dry matter accumulation up to 40 days after transplant, the heading stage, while the decrease in P concentration after 40 days indicated a reverse in the rate of the two processes and a dilution of P in the tissue in the same manner as discussed in the case of N. The concentration of P in the heads ranged between 0.3% at head initiation and 0.13% towards the end of the season. The pattern of P concentration for stems and heads very strongly suggested translocation of P from stems to heads following head initiation. This translocation was also indicated by the total P content of triticale stems which increased up to the heading stage, then started to decrease up to maturity while that of heads continued to increase from head initiation to maturity.

In rye, the concentration of P in stems fluctuated between 0.5% and 0.05%, tending to decrease with age; the concentration in the heads fluctuated between 0.35% and 0.10%.

Total uptake of P in rye was almost twice that of triticale (Fig. 5). At the end of the season the P yield of triticale was 15.5 mg/pot, with 32% contained in stems and 68% contained in the heads. In rye, stems and heads accounted for 62% and 38% of the total 15mg/pot P yield, respectively. As in the case of N, triticale heads accounted for most of the P yield of the plant, while in rye the stems accumulated most of the P in the plant.

Potassium. Roots were not analysed for K because it was thought that the washing process used in recovering the roots leached out most of the K. A random check on some root

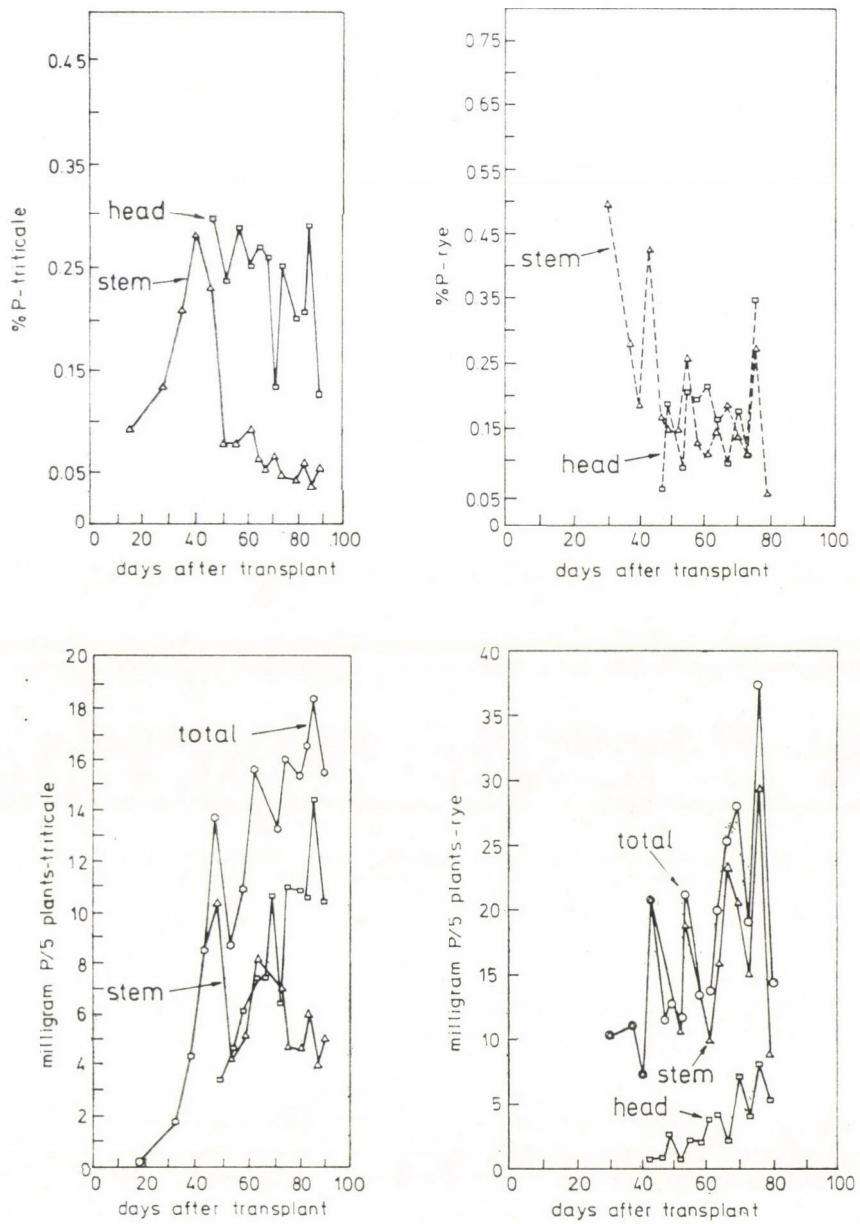

Fig. 5. Phosphorus concentrations and total uptake by the plant during the growth season

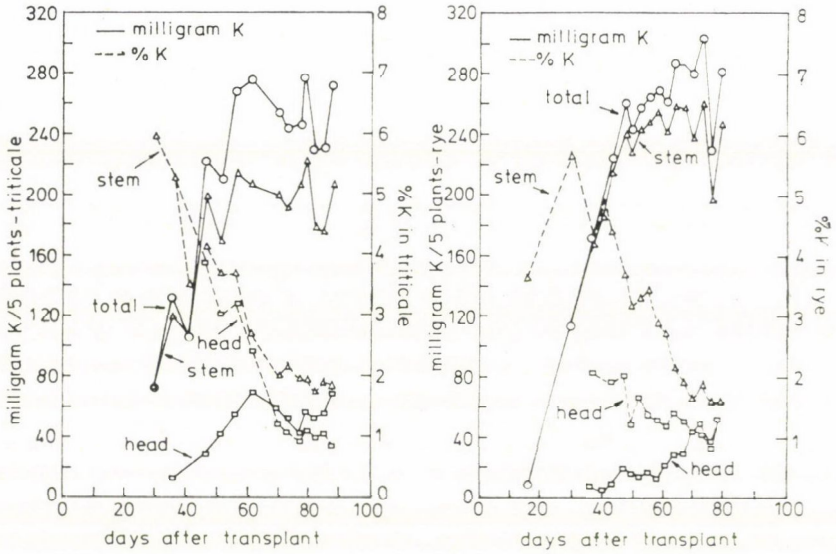

Fig. 6. Potassium concentrations and total uptake by the plant during the growth season

samples showed concentrations between 10 and 40 ppm K. Concentrations of K in triticale tems and heads decreased from 6% and 5.2% early in the growth season to 1.9% and 0.8%, respectively, at maturity (Fig. 6). Rye stems showed an initial increase in K concentrations when it peaked at 5.8% around 30 days after transplant; subsequently there was a continuous decrease, reaching 1.7% at the end of the season. Potassium concentrations in rye heads ranged between 2.0% at head initiation and 1.2% at maturity. The dilution in K concentrations of the plant tissue as well as the initial concentration increase in some plant parts are explained in terms of the differential rates of growth and K uptake discussed previously for N and P.

Total K uptake by the two species was approximately the same (Fig. 6). At the last harvest, stems and heads accounted for 85% and 15% of the K yield in triticale and for 79% and 21% of the K yield in rye. Stems rather than heads accounted for most of the K content of both triticale and rye plants.

Rate of Nutrient Uptake and Utilization

Mean uptake rates I of N, P and K, as well as mean utilization (assimilation) rates $\bar{I}$ were calculated using equations (1) and (2) respectively. The mean uptake rate values are plotted at the mid-period over which the nutrient flux was averaged for all the roots at the given time period of plant growth.

Nitrogen. Ranges obtained for I values in mg N per metre root per day were 13.8×10^{-2} to 2.2×10^{-2} for triticale and 37×10^{-2} to 0.11×10^{-2} for rye (Fig. 7). There are apparently no data available in the literature on the mean rate of uptake $\bar{I}$ for triticale and rye, though some data are available on corn. The values of I obtained in this study were comparable to those obtained by WARNCKE—BARBER (1974) for corn grown in the greenhouse (16.7×10^{-2} mg N m^{-2} day^{-1} at 18—25 days to 1.4×10^{-2} mg N m^{-1} d^{-1} at 74—81 days of plant age). MENGEL—BARBER (1974) obtained I values of 133×10^{-2} to 2.8×10^{-2} mg N m^{-1} d^{-1} for corn in the field at 18—25 and 74—81 days of plant age, respectively. The mean utilization rate values $\bar{I}$ for N (Table 1) by the two species, calculated using equation (2), also tended to decline with plant age.

Phosphorus. Values obtained for I ranged between 8.4×10^{-3} to 0.46×10^{-3} mg P m^{-1} d^{-1} for triticale and 2.9×10^{-3} to 0.006×10^{-3} for rye (Fig. 8). These values are much lower than the I values obtained by WARNCKE—BARBER (1974) for corn; values for corn in the field obtained by MENGEL—BARBER (1974) ranged between 15.2×10^{-2} to 31×10^{-2} mg

P $m^{-1} d^{-1}$ at 18—25 days of plant age. The mean utilization values declined with plant age for triticale but not for rye (Table 1).

Potassium. Values obtained for I ranged between 45.33×10^{-2} to 0.27×10^{-2} mg K $m^{-1} d^{-1}$ for triticale and 51.38×10^{-2} to 0.62×10^{-2} for rye (Fig. 9). These values are comparable to those obtained for corn in the greenhouse by WARNCKE—BARBER (1974), which ranged between 24.6×10^{-2} at 18—25 days and 2.0×10^{-2} mg K $m^{-1} d^{-1}$ at 74—81 days; for the same plant ages, MENGEL—BARBER (1974) reported I values for field-grown corn between 120.9×10^{-2} and 1.1×10^{-2} mg K $m^{-1} d^{-1}$. The mean utilization rate values (Table 1) declined with plant age.

The distribution of nutrients among roots, stems and heads can be obtained more readily in the greenhouse than in the field. Knowing the nutrient content of stems in the field,

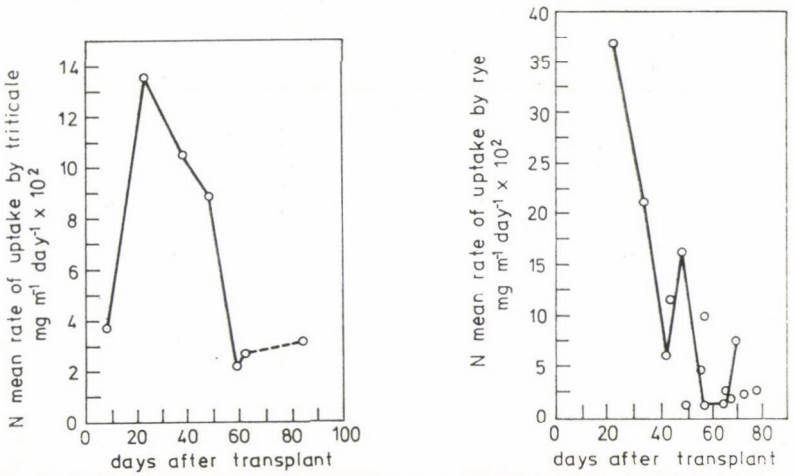

Fig. 7. Nitrogen mean rate of uptake by triticale and rye

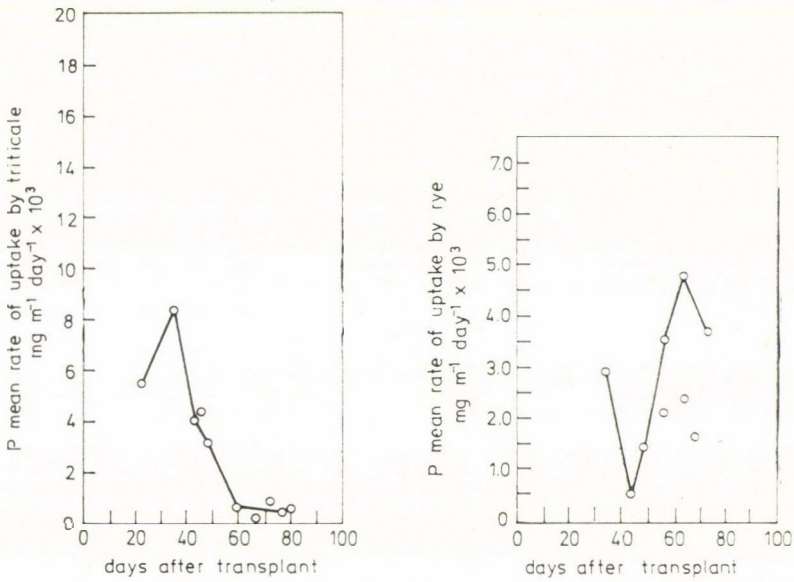

Fig. 8. Phosphorus mean rate of uptake by triticale and rye

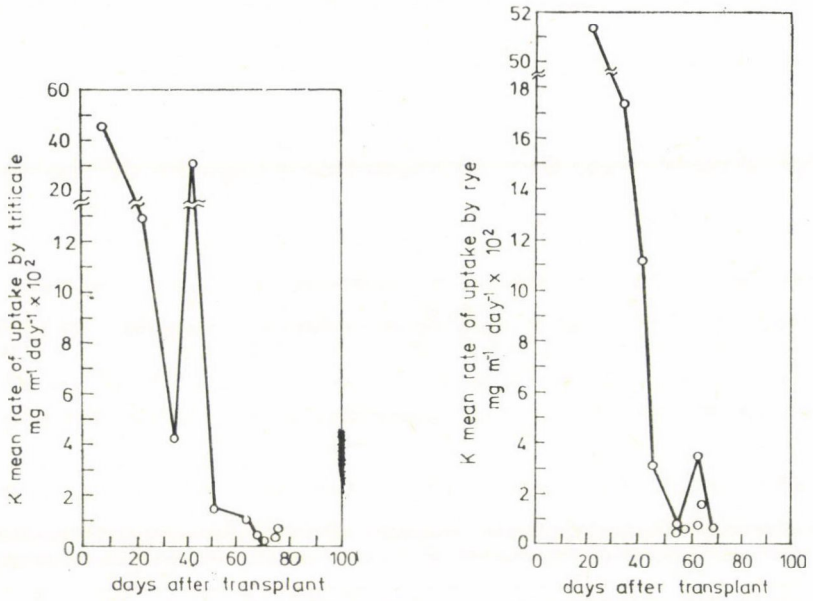

Fig. 9. Potassium mean rate of uptake by triticale and rye

this distribution may be used to predict the total nutrient uptake of the crop. This information could be useful in avoiding nutrient stresses in the field and in meeting the plant nutritional requirements. The different patterns of nutrient distribution and accumulation may be considered with regard to crop selection and utilization. Values obtained for mean rate of uptake for different nutrients in connection with total uptake could be of importance in designing adequate fertility programmes for the crops in question.

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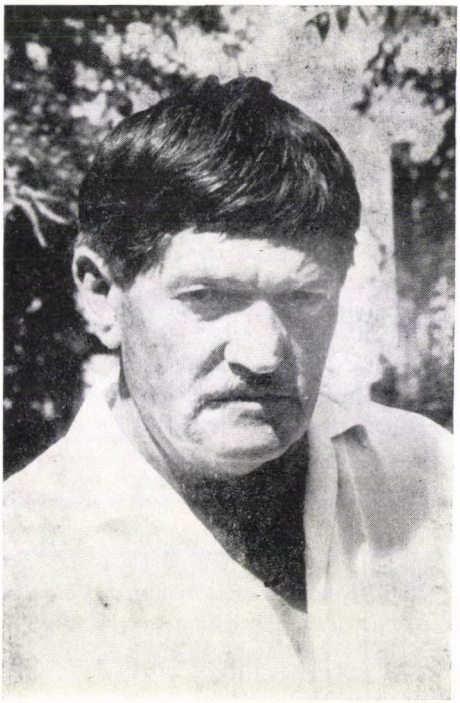

OUR GUEST IS

GYULA FEKETE

VICE-PRESIDENT OF THE HUNGARIAN WRITERS' ASSOCIATION

PÁL, GY.: *Mr Vice-President!*

Ever since the fratricide committed by Cain, first-begotten son of Adam and Eve, and the first tiller of the soil, who killed his brother Abel, the herdsman, because it was he whose offering was accepted by God and whose land became more fertile, the tiller of the soil has been looked down upon. The oldest contemporary of Jesus, rabbi Hillel writes: "We must not sell anything to the amhareces (peasants), nor buy anything from them, nor stay in their houses, nor receive them in our houses, nor teach them law." Of the peasants accompanying Jesus the Judaean scribes say: "But this people who knoweth not the law are cursed" (John 7, 49). What, in your opinion, is the reason why agricultural work, is socially underrated even today?

FEKETE, GY.: If we think about it, to begin with, tilling the soil was merely a supplementary occupation that made a very modest contribution to the living standard. For nomadic peoples who lived by gathering plants for food, and by fishing and hunting, we can

hardly speak of tillage, and even later, long after they had settled down, animals were still the basic index of wealth, and livestock raising, together with hunting, sometimes for game, and sometimes for strangers, either those who lived on neighbouring areas or those who invaded the land they had taken possession of (it is too early to use the term country), remained the main occupation. Tilling the soil was regarded virtually as a household chore, woman's work, where men only helped when they were too old to fight, hunt or tend animals.

By the way, I should not call pastoral nations engaged in nomadic stock-farming peasants; they did not regard themselves as peasants either, even thousands of years later.

In later centuries the most difficult and dirtiest part of the tilling work was done mainly by slaves, then by serfs, and this general picture is hardly changed by the fact that Cincinnatus perhaps really grabbed the handle of the plough, that the gentry were not much better off than the peasants, or that Tolstoy reaped the corn with his centurics they became the typical representatives of backwardness, simplicity, low intellectual demands and coarseness. Noblemen, soldiers, courtiers, and later citizens, craftsmen, in short: every freeman found plenty of reasons for despising them.

This was the situation, at least until the abolition of serfdom.

As we know, Hungarian society inherited a considerable number of feudalistic traits (we have still not rid ourselves completely of this legacy), so why should the undervaluing of the peasants who have replaced the sefs be an exception. In high society it was an insult to call somebody a peasant; characteristically, this was true even in times when the political parties were already competing with each other to gain favour with the peasants, when they called the peasantry "the pillar of the nation" and were unsparing in their praise of their soundness, diligence and political maturity. All with the aim of capturing the peasants' votes, of course, since even at that time, when voting rights were restricted, the agricultural population formed the majority. However, this majority was tied through its work and destiny to the villages, which lagged far behind as regards the level of civilization, so that the historical reason for disparagement remained.

In the fifties it was the peasants who suffered most from the dogmatic policies (compulsory delivery to the state, kulak list, aggressive organization of co-operative farms), new reasons were added to the historical ones, and millions of young peasants fled from the land. The slogan "worker-peasant alliance" itself was made to sound, due to misguided political practice, as if the peasants, the workers of agriculture, could never be anything but second-rate citizens placed strictly behind those of industry, communication, construction and service in every case.

The reasons are now fading, or have disappeared completely, but ingrained social attitudes change very, very slowly.

*

PÁL, GY.: *Ferenc Móra, the famous Hungarian writer, relates the following: "When I showed the editor the manuscript of my peasant novel, the editor, the businessman, who sees with the eyes of the public instead of his own, shook his head. 'My dear sir, what are you thinking of? A two-volume novel about peasants?' 'Reymont's novel is twice the size.' 'Yes, but that's about Polish peasants. That is quite different, you know. The Norwegian peasant, the Russian peasant, the Spanish peasant: by all means, they are willingly accepted by Hungarian readers. But who in Hungary is interested in the Hungarian peasant?" Why do you think the Hungarian peasant was not accepted in Hungarian literature?*

FEKETE, G..: I should not say that Hungarian literature did not want to accept the Hungarian peasant. After all, Petőfi built a holy church in his poetry "that may be entered even barefoot". Then there was Katona's Tiborc, the whole world of Arany's poetry, the Palots people in Mikszáth's novels . . . and Móricz's peasant heroes would make up a small town. It was more a question of the book-buying public having an aversion to Hungarian peasants. Or, to be more exact: to Hungarian peasants represented with artistic realism; the exotic was welcomed by the readers, the "Falu rossza" (The village rogue), "A betyár kendője" (The outlaw's kerchief), the peasant operas, and even Mikszáth's Palots people, the Dani Túri of Móricz's early years and Tömörkény's peasants, because in these strange peasant heroes they felt something exotic. It may be true, on the other hand, that peasant stories faithfully reflecting the dark side of Hungarian reality could not be a hit in Hungary for a long time.*

There is nothing exceptional in this. The Hungarian bourgeoisie and intelligentsia have always inclined to snobism. Even though they willingly read about Russian, Polish or Spanish peasants, I hardly think they were attracted by the subject. Let us not forget that in high society the knowledge of a foreign writer gave a better opportunity to excel than speaking of a Hungarian novel, no matter how talented its writer was. In the twenties, three hundred Courths-Mahler novels were sold in the bookshops for every Móricz volume that found an owner. Just compare these facts with the inverse ratio between Móricz' and Courths-Mahler's greatness as writers. The Hungarian public only took notice of Bartók — and even then unwillingly — after he had created a stir with his concerts abroad. Kodály's choral works were hooted by an audience at Győr, but when the stubborn conductor included choral works by Kodály in the programme under the name Singenberger, the same audience burst out in frenzied applause.

Need I continue? Csontváry?[1] Attila József?[2] . . .

This snobism is by no means a thing of the past that characterized only the upper classes of the old social system. It exists, acts and flourishes even today, choking literature, art and science.

Nevertheless, the truth of the matter is that Móra's editor proved to be a false prophet. The Hungarian peasant not only appeared on the literary scene in the mid-thirties, but has played a leading role ever since. He has made an emphatic appearance in every type of work, but has gained most prominence in literary sociography and has turned the previously limited reading public of this form of literature into the most populous readership.

Peasants have entered literature not only as heroes but also as writers. The movement of the "populist writers" grew into the most important intellectual movement in Hungary between the two world wars; I must be content to characterize it with a very restricted list of names: Péter Veres, Pál Szabó, István Sinka, Áron Tamási, Gyula Illyés, László Németh, Imre Kovács, Ferenc Erdei, István Nagy . . . and many others. They drew a new audience not only from students and young intellectuals, but from interested workers and peasants too, and this intellectual trend called into existence a new publishing house, that of Sándor Püski, which in the course of the years became the most popular publishing house in the country, with such a wide circulation that it could have been the envy even of the one-time bestsellers.

* The characters listed are taken from Hungarian poets and novelists of the 19th and 20th centuries.

[1] A famous Hungarian painter.

[2] A great Hungarian poet.

Just one more comment on this: this was not simply a new craze in literature. If we think about it, at a time when large estates sprawled all over the country and the remains of feudalism crippled public life, this literature raised, and partly even answered, the problems of the age, the most exciting public questions; it was this literature that represented both in artistic level and permanence the main trend in Hungarian literature.

*

PÁL, GY.: *The amount of land which could be held by a serf consisted of a near-lying area consisting of one cad.yoke (0.65 ha) and a more distant area of 16—40 cad. yoke of arable land, with an additional 6—20 cad. yoke of grassland for mowing; apart from this, the owner was entitled to a proportionate share in the use of pastures, forest and reeds. Ferenc Erdei writes: "The peasants were also similar to one another in that they all had serfs as ancestors, and that their present morals stemmed from the serf society." In the fifties, a smallholder who owed his freedom to the fights and struggles of progressively minded ancestors became a class-alien reactionary, was put on the kulak list and condemned to liquidation. How can you, as a humanitarian, reconcile the fight for the abolition of serfdom with the class battle against the descendants ?*

FEKETE, GY.: In no way. The struggle for the abolition of serfdom made its way along the main path of history, in the direction of social progress. The so-called kulak liquidation was a dead-end, where society rushed headlong into disaster.

I will try not to be prejudiced, though my father was also a smallholder who was put on the kulak list. In the middle of the twenties, when the Pengő was introduced, my grandfather bought land with a bank loan. From then on the family virtually worked for the bank to pay the interest — 16% for many long years — regularly, as they were totally unable to amortize the loan. Later my father inherited both the land and the debt, and though he never had any servants, nor employed any seasonal workers, he could not get rid of the bank loan as long as the Pengő was the national currency. Though branded as a kulak, he lived with his family in a house which had a single room with a dirt floor and 60—80 year old furniture. In 1948 my brother and I persuaded him to offer his land to the state without compensation, as we did not wish to claim it, and to keep about three cad. yokes, which would be enough for him to potter about on in his declining years. The land was taken over by the local co-operative farm, but two years later my father was put on the kulak list and ordered to pay absurdly high taxes and deliver a large quantity of produce, just as if te still possessed his land. And since he did not — could not — fulfil the levy, he was interned. Later he was allowed to go home for a short period, but was soon interned again because he had not worked his land while he was in the internment camp. The strangers who were quartered in the house beat my mother up — I do not want to go into details, but only wished to indicate why I must take care not to be prejudiced.

I might add that I was the ministerial commissioner for land distribution in Borsod County, and agreed wholeheartedly with the slogan "The land should belong to those who cultivate it!" But the decrees were not based on this principle at all; not only was the undivided cultivation of family estates not respected, but neither was the quality of the land, which varied considerably from region to region, or the manner and standard of cultivation; orchards and vineyards were charged with a fivefold tax, i.e. in many cases the progressively minded small peasants were also qualified as class-enemies.

But quite apart from all this, the main point as I see it was the inhumanity of political practice. In those years not only the small group of peasants declared kulaks and class-enemies, but almost the whole peasantry became completely defenceless. Unlawfulness prevailed all over the country, no one could feel safe. Let me give just a single example of this.

B. K. was a personal acquaintance of mine, whom I have already written about. In 1947, as a peasant cadre, he was appointed managing director of the Seed Trade Enterprise, but having heard disturbing news from home he resigned his post and went back to his village to organize the local co-operative farm. He fell out with the district administration, was put on the kulak list, expelled from both the party and the co-operative farm, and even prevented from finding employment elsewhere. It was only years later that I succeeded in finding out on what grounds that poor peasant with seven children, former president of the local land claims committee, who, in the course of the land distribution, was granted 1.5 cad. yoke over and above his own one yoke of land, had been qualified as a kulak.

"He had 28 cad. yokes of land on lease." (The 1—2 cad. yokes of land which he leased from year to year were added up, and amounted to a total of 28 cad. yokes over 25 years.)

"He employed hired labour." (On certain occasions, mostly when his wife was having a baby, he needed help for a few weeks or months to get his produce to market.)

"He used to be a managing director." (The past, in this case, as I mentioned above, was in 1947—1948, as a promoted peasant cadre.)

There was no question here of principles, simply a distorted wielding of power. Even the excuse that this practice only "distorted" our correct socialist policy seems to me to be an insult to our socialist principles.

In actual fact, the commodity-producing capitalist form of economy was far from being dominant in Hungarian agriculture. Accordingly, the distribution of the peasants into capitalist land-owners and agricultural proletarians did not separate them sharply into two classes with conflicting interests, and even the exploitation was not of capitalist character, but of a much more complicated nature. While on the large estates feudal conditions were still in existence, on the smaller estates the relationship between the owner and his seasonal workers and servants was characterized by a kind of patriarchal form inherited from the past. In this peculiar system of relationships the farm servants and the share-croppers, who came regularly for years over long periods, were considered, together with their families, almost as distant members of the farmer's family. Decades have passed since these business relationships broke off, but as human relationships they exist in many cases even today. Not long ago I saw a family photo of a one-time farm servant on the wall among the family photos of a farmer at Öcsöd, who is now over eighty. He is sometimes visited by his former servant even now, if not on other occasions at least at Christmas time, on his name-day.

All this is only to indicate that the peasant policy of the fifties was far from being based on an "analysis of the actual situation".

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PÁL, GY.: *In order to catch up with the western countries in capitalist commodity production Austria wanted to reach a higher level of industrialization, and planned to develop Hungarian industry too, but the nobility of Hungary refused to give up its immunity from taxes. Austria, therefore, changed its policy and from that time on hindered Hungarian industrialization at any price, because, owing to the protective tariffs, the surplus agri-*

cultural production went towards meeting the expenses of the Empire. In order to increase the quantity and quality of agricultural production Austria thus tried to ease the position of the Hungarian peasantry. (Maria Theresa's Urbarium, Joseph II's decree on the protection of serfs.) Why, in your opinion, did the peasantry of Hungary remain Hungarian in spite of the serf protection orders of the two Habsburg rulers ?

FEKETE, GY.: It was not a particularly long period of history. Certainly not long enough to erase from the instincts of the people the traditions of the Kuruts rebellion, or to efface the bitter taste of the German poison and the anti-German feelings accumulated in the course of centuries — as reflected in our folk-songs. It is possible, though, that the naive respect for kings detectable in the public mind even at the beginning of the present century can be traced back to that period.

It would have been against the rules of nature if the Hungarian serfs had responded to royal patents which were alternately benevolent and manipulating by giving up their language. Give up their native language? (There can hardly be any question of the serfs having had any national consciousness at that time.) Repudiate their culture and traditions? Large ethnic groups cannot be brought to do so either by persuasion or by force. Scattered groups of people are much more liable to do so.

And let me add: the Germanizing policy met resistance over fairly large areas from the "Hungarian religion", the popular basis of the Reformation, and also by the gentry which has been much disparaged lately, but which already had a definite national consciousness at that time. They were impoverished country gentlefolk who led a peasant's life, and who certainly had a strong influence on the serfs' way of thinking.

Where was the sophisticated manipulation of the mass media, the sly policies that now swallow nationalities, and that induce or force hundreds of thousands of people to give up language, culture and identity in an amazingly short time!

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PÁL, GY.: *Jenő Nagy, general editor of the "Fejér megyei Hírlap" (a county newspaper), having recently made a tour of the farm-steads of the Mezőföld, a region in the south-eastern part of Transdanubia, writes: "The order, the discipline that had to be kept by everybody in the old farm-steads is a thing of the past. The steward gave strict orders as to where the servants' sties, pens, stacks, vegetable gardens, lavatories, etc. were to be established. Furthermore, the course of whitewashing, cleaning and disinfecting was also specified . . . Since, however, no one has lately specified what should be done when and where, and since no-one exercises any supervision, the most appalling chaos and disorder prevail in the farm-steads." Why do you think the sties, pens, haylofts and barns in the farm-steads are now huddled up in bewildering disorder 2—3 metres in front of and behind the former quarters of the farm-servants ?*

FEKETE, GY.: I am afraid it indicates that the inhabitants of the farm-steads have still not got rid of the servants' way of feeling and thinking. And what is more: not only the former farm-servants but their grown-up children and grandchildren have not yet shaken off these remnants of the past either.

After the land reform it was only for a couple of years that they owned the allotted lands, and even those few years were an endless struggle as they had virtually no draught-animals, no tools, no implements, and insufficient farming experience. Those years were too short and too full of vicissitudes for them to develop the consciousness and sense of responsibility of a landowner.

However, a viable, healthy co-operative farm should be a voluntary socialist association of people with such consciousness and responsibility. Many of those who were short of consciousness and of this kind of responsibility for so long, and who were independent farmers for so short a time, seem not to have acquired independence and the consciousness of being the owners even in the co-operative farm.

Many of those who had been agricultural workers on large pre-war estates certainly could not perceive any great historical change in the co-operative farms of the fifties and sixties compared to the one-time estate. There were large fields, big farm buildings and machines in the co-operative farm, too (the machine park and livestock of the fifties were hardly more developed than those of the thirties and forties); there were people who gave orders, who specified from day to day where the manure removed from the stables should be put and what work should be done when. Though these new people did not keep such strict discipline as the old ones did, and sometimes kept no discipline at all.

But I still say it is not discipline, prohibitions, or obligatory orders that are wanted here. The situation could probably be improved by demolition orders, by prohibitions and penalties — as the treatment of symptoms is usually successful. After all, the disorder which is now rife around the former servants' houses due to the absence of strict orders, prohibitions and discipline is a symptom, and only one of the symptoms of the servile mind and attitude which are ruled by the idea that instructions and prohibitions must be observed — even if only in a perfunctory way. On the other hand, without instructions and prohibitions servile people become uncertain and do not know what to do with themselves and their lives.

To be sure, this servile way of thinking may show far more adverse symptoms than the disorder around the house. It is the after-effect of a bygone way of life, the vacancy of inertia. People who are middle-aged today have no experience of being a servant, and for their children even the memory is little more than oral tradition. However, the way of life perpetuates itself, some remnant of it is handed down from generation to generation, no matter how conditions have changed. Mental shocks, strong impacts, or, if these are lacking, time, time, and more time is required for social groups to adjust their views, expectations and way of life to the era they live in.

Living in the same old environment and social medium itself has a preserving effect in these isolated farmsteads. The villages, for example, have developed in a spectacularly different manner. There are many newly built houses in them, with well-kept gardens, showy fences, etc.; the inhabitants watch and secretly compete with each other — in short, for some decades enormous progress has been made in pretensions of this kind. This could hardly be said of intellectual demands.

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PÁL, GY.: *The relativistic view that "De gustibus non est disputandum" (There is no accounting for tastes) was a basic axiom of aesthetics. In recent years even elderly women living in closed ethnic units have proved willing to sell their national costumes, masterpieces of embroidery which they once laboured at day and night. This may be due, on the one hand, to their being so ashamed of the past, of their poverty, that they wish to get rid even of the memory of it. On the other hand, being old and unable to work they may need money, or some of them may want to keep abreast of the fashion. What do you think is the reason for this phenomenon ?*

FEKETE, GY.: Village people no longer part with the requisites of peasant life as easily as they did even ten years ago. If nothing else, the large number of hucksters have made

them aware of the value of these objects, and they now realize that they can get money for them aware of the value of these objects, and they now realize that they can get money for them. Obviously, the people who buy them will pass them on at much higher prices if they often find it worth travelling considerable distances to obtain them. And not only the old hand-made embroidery, crocheting and national costumes crammed into the bottom of the chest of drawers have increased in value, but milk-jugs, mangles, copper mortars, carved salt-cellars, or even the old tools, wheel-distaffs and yoke-pins lying about in the loft of the pig-sty are also in great demand. The obvious reason why objects like this were so readily sold at first was that they were no longer considered valuable, but simply increased the mass of useess junk in the peasant yards, handed down from generation to generation. Anything which was no longer used and which was unlikely to be of use in the future lost its value in the eyes of the peasant. And the national costumes and other pieces of folk-craft embroidered with such pains have long since been replaced by articles of urban fashion, the hand-made tools by manufactured goods, while flay-stripping, weaving and pinning, bread baking and many other peasant activities have no part in the new way of life.

It is also true that these objects are reminiscent of poverty and the hard life, and this poverty is like a bad memory from the past: it gets forgotten, or what is not forgotten of it is no longer mentioned, or is even denied. The grandchildren of those who were the poorest in the past hear very little within the family about the miserable existence of their grandparents, who starved, wore ragged clothes and made tea from bread crusts. Reports and sociographs prove that the misery of the past is something not only to be ashamed of but also to be denied.

Furthermore, the money received for odds and ends which are no longer used or valued certainly comes in useful to add to the very modest pension from the co-operative farms and to the still more modest old-age allowance.

But there is another aspect to this, too.

As I have said, they already know that anything dug out of the chest or from the pigsty loft is now appreciated in the town, renovated and hung on the wall, or placed among the modern furniture. So they would gladly give thete things to their children — if they had any. But most of their children have left the village and live in tiny flats on housing estates, where they have not enough room even for the most necessary things, so they have no interest in such presents.

So what will become of these objects which are left in the homes of the old? If there are no children in the family who will inherit the home with all its belongings, in which case it will be up to them to decide what to keep and what to throw away, the fate of these unused articles will inevitably be destruction. Perhaps even the old adobe house will be bought only to be pulled down, and the number will be put on the bonfire; children who live far away and only come home for a couple of days for the funeral have more important things to think about than turning the junk into money!

So why should they not sell them when the huckster comes, if someone can make use of them. They do not care if they are not hung on the wall, just locked at from time to time: even this is better than destruction.

Many of them would give these objects away for nothing if they knew that they would be cared for. Wardens of village museums could tell many a tale of how willingly old people present them with valuable embroideries that they once strained their eyes to make, or even with antique objects that could be sold for a good price, as if they were saving a piece of their lives from death.

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PÁL. GY.: *"The farm-stead (puszta) was generally built in a place where there had once been a village, and the name retains the memory of the fact of devastation (pusztulás)." In the last half century profound social changes have taken place in these isolated farmsteads and in the villages too. Due to the land distribution the farm labourers, a social stratum with a high natural rate of increase, ceased to exist; then, through the co-operative movement, the small-holdings, which were capable of sustaining a large number of people were also eliminated. In your opinion has the socialist type of large farm anything to do with the fact that the natural increase in the population in Hungary was 6.0 per thousand in 1975, 5.0 per thousand in 1976, 4.3, 2.7 and 2.2 per thousand in 1977, 1978 and 1979, respectively, and is now zero ?*

FEKETE, GY.: What is worse, there is not likely to be any natural population increase in Hungary within the foreseeable future. According to demographic forecasts, an accelerated rather than a gradual decrease and ageing of the population, and an increasing rather than a steady rate of deterioration in national vitality can be expected over the next forty years. ("Population of Hungary, 1980—2021." Reports of the Institute for Population Research of the Central Statistical Office, and the Demographic Committee of the Hungarian Academy of Sciences. No. 49, 1980.) To characterize the acceleration of the destructive decrease, the projected annual rate of decrease will be

18,000 in 2000,
32,000 in 2005,
48,000 in 2010,
54,000 in 2015,

and over 54,000 for the rest of the period concerned. Year by year there will be more coffins than cots by a number amounting to the population of a town the size of Veszprém.

By 2021 the accelerating decrease will reduce the present population of Hungary by 1,251,000 to below 9.5 million. But the actual decrease in the rising generations, in the number of those still to be born, offers an even darker picture. By 1996 the already smallish age-group of children aged from 0—14 years will decrease by a further 555,000. In our ageing society the proportion of young age-groups is unfavourable even today. This miserable proportion will shrink at a frightful rate over the next 40 year, and the number of people in the 0—39 year-old age-groups still to be born will be 1,703,000 less. This sad fact is the most important information on our future; in comparison to simple reproduction, i.e. to the long-term maintenance of the population we shall be short of 1,703,000 people. According to the projections the debt in the births column, associated with a zero increase, will amount to this in the course of forty years.

(I must add: I have quoted the data of the most probable version of the prognosis; however, in comparison to the actual data of the period since 1979, when the prognosis was drawn up, even this version seems to be far too optimistic. So much so, that it is already under correction, and the new version predicts still more mournful data for the future.)

There is no room here to analyse the processes outlined by the numbers quoted. There is really nothing mysterious about the disastrous deterioration of our demographic situation. The concrete causes that numb even healthy instincts are present to such an extent that we should be more surprised, if we really want to look for mysteries, if a disastrous decrease were not the result. For decades now, the incentives, not only of a financial, but of an ideological, conceptual, political, legal, etc. nature, have been exercising an irresistible force from all directions to "encourage" people not to have

children, or at least not more than one per family. And this "encouragement" is perceptibly strenghtening at present. (The financial aspect — an important though not decisive factor in the counter-encouragement — can be clearly demonstrated. The more comfortable way of life, with one or no children, gives more of a bonus from year to year.) It is impossible to list the numerous situations where the causes of our present hopeless demographic crisis still exist and continue to act. Moreover, some of the bitter fruits are still in the process of ripening: the new division of labour between the sexes, which disregards the primary interests of motherhood; the resence of anti-mother feminism in woman's policies; largely irreparable errors in the location of industry and housing policies. The innumerable tiny flats on housing estates built with no consideration of the law of continuity will make an effective contribution to birth control, particularly in the decades to come.

I will only mention briefly here what I have expounded elsewhere, that a new form of exploitation is spreading in the civilized world, more dangerous and noxious than any classic form encountered so far: the consumption, or "exploitation" of the future. (The most general way in which financial and other advantages can be obtained is by consuming life, by sacrificing the child, the "investment for the future". However, this category includes all those practices that subordinate future interests to current, momentary ones: environmental pollution, soil destruction, the ruthless exploitation of energy sources, unreasonably long-term or badly utilised loans which will have to be repaid by the children or grandchildren, etc.).

To return to the original question: does the socialist type of large-scale farm with its lower ability to sustain the population play any role in the reduction of the birth rate in Hungary?

I believe it does play some role, though this role is only secondary, since the above-mentioned "incentives" against having children make their effects felt in large-scale farms as well.

I do not think the problem is really the decreasing capacity of agriculture to sustain the population. In a well-organized, dynamically developing farm the newly established up-to-date occupations snatch up with unquenchable appetite the labour that has become superfluous in other sectors. But there is something here that the civilized world does not take into account at all, though it is a process which has been under way for two centuries in Europe. In Hungary it has only assumed social proportions over the last few decades: the production-centred type of family has been replaced by the consumption-centred one. In the former type, for example in landed peasant families or even for day-workers and farm servants, the child was a help, a working member of the family, a sustainer of the old and a tender of the sick, from a very early age. In the latter type of family, living from wages or salaries, the children do not increase the income of the family, but on the contrary, consume it until they are able to earn their own living, and even then the family can hardly rely upon them. The incentives have thus undergone a complete change, the signs have been reversed: the child was previously of vital importance for the type of family where the members carried on production tasks in common, and has become an expensive, and dubious, source of pleasure (according to many: a hobby) in families living on wages and salaries, where the smaller the family the larger the per capita income. (Nor must it be forgotten that in the meantime the era of contraceptives has set in.)

Old-age provision has been introduced on a social scale; today everyone has a pension. Since individual progeny are not required for this pension, many people fail to realize that a sufficient number of progeny is still a social necessity. Only live labour can produce the national wealth required to cover pensions and provide for the old.

It can also be proved by theoretical reasoning that the prevalence of anti-child "incentives" is mostly a problem of income distribution, and is related with the socialization of agriculture only in this sense.

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PÁL, GY.: *In the last ten years more than half of the sum allocated to town and country planning was used up by Budapest and the five cities with county status, and the larger half of the remainder by the county towns. A much smaller proportion fell to the share of secondary centres and very little to the villages. Consequently, more people moved to the big towns than was planned or calculated, and the inflow absorbed the larger part of the funds available for the development of the towns, so there was virtually no urban development in the towns either. Do you think that under such conditions the ability of the villages to retain their populations can possibly increase ?*

FEKETE, GY.: Under such conditions, certainly not. Even if there were a radical improvement in the conditions I can hardly imagine this happening, since a misguided town and country planning policy has started processes that can no longer be reversed.

Sometimes I wonder what the future of the tiny hamlets in the Cserehát and Szárazvölgy areas of the hills of Borsod, my native county, will be. And what will become of the tiny hamlets in Baranya, Somogy, Zala and Vas counties? How long will the planning principle that stemmed from a dogma that never had any validity, namely that a certain number of inhabitants is required if a settlement is to be viable, a principle which served as the excuse for erasing two thousand villages from the map of Hungary, a nightmare masquerading as a concept — which has luckily proved a failure — how long will this continue to cause damage?

At the time when the village of Gyűrűfű ceased to exist the nation-wide reaction was like the tolling of alarm-bells; since then many of our villages have met the same fate and vanished from the map, but without raising any outcry, and between the last two censuses, over a period of ten years, the population has been reduced to half in numerous tiny hamlets. How much of this process is necessary, in line with the main trend of socio-economic development and thus acceptable, and how much is compulsory, forced, harmful and therefore unacceptable?

It is well known how the settlements were graded, how they were classified as "lower", "higher" or "priority" by someone sitting at a writing-desk; but then, within a few years — an amazingly short time compared to the age of the villages, some of which are many hundreds or even thousands of years old — it turned out that life is no respecter of strict categories, or of the hierarchy which is now qualified even officially as being of feudal character; it sometimes happens that priority settlements stagnate in spite of preferential treatment, while the downgraded villages develop in spite of the drawbacks. Moreover, new settlements spring up with several hundreds of inhabitants and rows of modern houses: in Bács-Kiskun county alone 60 villages of this type are registered; they are not included in the development plans and therefore have no "birth certificate", no official name, only nick-names inherited from some part of the countryside, etc.; they have no local government or administration either, so for the time being they namelessly increase the number of hamlets without municipal councils. Will they prove to be viable? It seems very likely that they will, if only because of the fact that they came into existence, for the time being as hamlets, at a time when other hamlets were dying, not infrequently in spite of the so easily issued prohibitory building restricitions and in some cases even after a ban on shops selling

fundamental items. And the situation of farmsteads varies in a similar way according to the local conditions: in some regions they are deserted, while in other places with more favourable conditions they have adjusted to the new circumstances and are flourishing.

What, then, is to be done? Should the farmsteads, villages and towns be left to their fate, whatever that may be? And if not, how could the development be promoted wisely and flexibly without trying to force concepts through? It is quite obvious that changes in farming methods have an effect on the structure and density of the villages and also on their ability to sustain the population. The changes are of historical dimensions. It is enough to glance at Hungarian industry and agriculture to realize that these are no empty words. This being the case it is only natural that the development of various types of settlements is contradictory, and it is virtually impossible to put on paper what should be done, at least not with full particulars, only in outlines, in the form of projections. On the other hand, a projection only gives an indication of the arch of the bridge leasing to the future, while the pillars must be erected year by year from the ground of the changing reality — according to the varying needs, requirements and demands.

A further, still more difficult question is whether the arch of the bridge is correctly orientated in the plan? Is it certain that it points to the future? What is the future for the farmstead, for the village, for the town — in general? And in particular: for the given settlement? How much are the calculations to be relied on? There are many settlements and projects in Hungary that have consumed thousands or tens of thousands of millions from public funds, yet, according to present knowledge of the situation and considering the sometimes incalculable changes taking place in the world economy, under no circumstances would their future be orientated now in the direction once determined.

But if an insufficiently provident view, or dogma, or doctrine becomes so dominant that it does not tolerate contradiction, warning or criticism, and suppresses the desirable open discussion, it deprives itself of the possibility of necessary modifications. By the time it is forced to stop or turn back it has launched a whole range of processes that are no longer reversible and caused irreparable damage. Without an open debate between the competent persons, and anyone else affected, no bridges guaranteed to lead to the future can be built. What is needed is an open debate on principles and plans, with free competition between settlements, for example, or between forms of settlement. Advantages and drawbacks should not be decide with a wave of the hand by the bureaucrats; unheard-of preferences must not be granted to those that have not yet proved viable, nor should those which may still give evidence of viability be suppressed. A prudent town and country planning policy has a sense of proportion: an advantage given in one place should not mean an insurmountable handicap elsewhere.

It is obvious, for example, that many of the investments necessary in big cities serve not only the population of the city in question but also that of the surrounding area, occasionally an area the size of a whole county, or even the population of the whole country, so it follows that laying the foindations for the future consumes a larger per capita sum in the city than in the village. However, the practice of giving 65% of the settlement development funds to Budapest and the five large cities, and only 1% to the villages, which have a total of two million inhabitants, has swung to the other extreme.

As one expert said, it can be decided "on the basis of the technical parameters of canalization", in other words: on the basis of drainage costs, whether a settlement

is viable; this sole point of view could become dominant in planning the future if a hundred other, mostly more important points of view are neglected or ignored. It is striking with what regularity enterprises launched with high expenses and great expectations come to a deadend when only one aspect is kept in view. And this has the inevitable complication, if I may call it that, of shortsightedness, when the believers, the lovers, the fanatics of the enterprise, concept or doctrine are only prepared to notice what justifies them, and completely ignore every argument, fact or alarm signal that witnesses against them.

Suppose, for instance, that the view that the housing estate is the most up-to-date form of housing and that the family house is obsolete becomes prevalent . . . We have only to take a glance at the latest housing projects in developed countries to see that the trend of development is just the opposite.

Suppose, again, that the opinion that commuting is inhuman, and that as many commuters as possible should move to the towns near their jobs becomes generally accepted . . . a glance at the world again suffices, and we may even arrive at the conclusion that commuting is the thing of the future. The only questions are the distance between home and job, and the state of the roads and transport facilities.

Suppose, yet again, that we become indoctrinated with the view that villages with less than one or two thousand inhabitants cannot be modernised as production and consumption units . . . This short-sightedness completely ignores the fact that the village is a social unit, a population-maintaining human medium, a community of birth and education, and a carrier of immensurable human values.

These are certainly difficult questions: where we will find the bridges that connect the present with the future. It seems as if our concept of the future has become uncertain. The socialist concept of the future, which is now fairly free of illusions, is more uncertain than it was in the daydreaming era. And so is the national concept of the future, not to mention the concept of the future in small villages!

Much indignation is expressed on account of the fashion for building massive, fully equipped, expensive crypts, although this is only a symptom: the ageing village no longer feels its future in the children, who have drifted far away from home; there is nothing left for them to build, so their concept of the future has gradually moved to the cemetary.

PÁL, GY.: *According to the literary view on co-operative farms the co-operative farm worker ought to be encouraged to consider himself as a proprietor rather than as an employee. Others prefer to emphasize the employee status, since in their opinion there can be no mention of proprietorship under the present conditions. It is complicated by the fact that in developed capitalist countries the owner does not always become both employer and entrepreneur: these roles have become segregated. In your opinion, is it possible today to find a type of proprietorship and methods of farming that would make the co-operative farm worker interested in production both as a proprietor and employer, and at the same as an employee and entrepreneur ?*

FEKETE, GY.: This is a very complex question. If I understand you correctly, the essence is: what would be the desirable socialist economic model, or to be more exact: the model desirable in Hungary?

I should like to emphasize: nobody can be always right and sure of himself in this matter, since the path towards a desirable model can only be found through suppositions. The ideally modern and ideally socialist model would certainly be one that co-ordinated the various forms of interest, that have been at war with each other for hundreds or even thousands of years, to the fullest possible extent.

Can this ideal be achieved? I should be satisfied if we succeeded in approaching it.

As a basic principle in trying to solve the problem I should suggest granting free rein to anything useful to the community and preventing or restricting anything harmful to the community or which damages other, innocent people.

The principle is easy to formulate, confusingly contradictory when put into practice.

I think we should take the actual situation as our starting point. In my opinion the co-operative farm workers have no proprietory role, just as factory workers have none. Consequently, the consciousness and responsibility of an owner ave not developed in them. The reality is a role of employee, but a sense of socialist consciousness and responsibility can only be built up through an adequate system of incentives. I am by no means thinking merely of financial interest and incentives. I am convinced, for example, that under socialist conditions the incentives offered to employees should include the enhancement of the proprietory role and functions.

Therefore, the natural order in which the problem should be tackled is as follows: since the role of employee is open to everyone, it seems reasonable to develop the employees' interest first of all, in such a way that the employees will learn a sense of consciousness and responsibility, by gradually increasing the proprietory role, too.

Proprietory interest based on the actual practice of the proprietory function is a relation incomparably stronger and, under socialist conditions, in quite another class as regards the state of development. As a matter of fact, proprietory interest, or to be more precise: the collective proprietor's interest, is a kind of basic texture of socialism; it is this that should prevail and penetrate the whole producers' society.

There is every indication that the conditions for the assertion of the proprietory role, interest and responsibility are far better in smaller units where the cohesive forces of the collective are more effective. These conditions are thus better in smaller co-operative farms than in giant farms that extend over the fields of several villages. It is probable that the proprietory role, interest and responsibility, like so many collective values, are most efficiently evolved in a direct democracy. Thus, even in large production units it is in the smaller groups, work-teams and sections that they can develop most naturally. And this probably happens to the greatest extent when the collective and private interests are in full agreement.

As to the employer's interest, I feel it is a function of the above. This can be interpreted, on the one hand, as something arising, though in a very indirect manner, from the awareness of proprietory interest, if the latter has developed at all. On the other hand, it could be put like this: under socialism everyone is an employee, including those charged with the employer's role, which means that the employer's job also involves organization and management, and in this direct, professional interpretation it can be included in the conceptual sphere of employee's interest.

But how can entrepreneurial interest be fitted in with socialism? Here I must go into more detail, because it is only lately that we have begun to take this ideological and theoretical fallow land into cultivation, though it seems that the competitiveness, viability and dynamism of socialism have considerable reserves here.

Take the homeplot, for example. We all know the old practice: discourage production in the homeplot so as to improve it in the collective farm. But in the course of time the reverse has proved more likely: the interest in production, whether it increases or decreases, goes parallel in the homeplot and the collective farm, because they have become so intertwined with each other, and the small private farm has become such an integral part of the socialist large farm.

But, after all, what is the homeplot? I should answer in one word: an undertaking. Whether it is aimed at merely producing vegetables, potatoes, fodder crops and fruit for the household, or at growing early vegetables under polythene, fattening pigs or raising chickens and other animals for market as well.

The word undertaking and the concept it implies has become defiled in Hungary over the last few decades. Even the dictionary mentions it with the following specifications: "before socialism", "incapitalist economies". In the course of time, the concept of an undertaking became closely associated with the idea of exploitation, which is how it became defiled. But then, what does the idea of exploitation mean? Anyone who has ever attended beginners' political classes ought to remember its meaning: "appropriation of goods belonging to others without compensation". Very many people have forgotten this fundamental notion, if they ever knew it at all. Otherwise the person who scraped valuable sour-cherry stones out of the garbage could hardly have been taken to court. And those who sweated among the gas burners in the heat of the summer making pancakes and fried dough would not have been cursed so much. Peasants who fattened 20—30 pigs, reared bulls and grew fruit and vegetables under hard, risky, and sometimes inhuman conditions on their homeplots, as well as working on the collective farm, would not have been abused. After all, that "goods belonging to others" were appropriated by them? And "without compensation" at that? Is it not more likely to have been simply envy that defiled and abused these undertakings, which were so useful to society? The envy of those who were not prepared to undertake extra work of this sort for the sake of the surplus income it would bring them.

The word undertaking has lately begun to gain socialist sanction, since, in addition to agriculture, the socialist "small forms" have shown a welcome increase in industry, transport and services. I have read in document: "In the socialist undertaking the entrepreneur operates the unit with great independence and almost with a proprietor's interest. At the same time he does so within the framework of an economic system which ensures that the whole community profits through the personal profit of the entrepreneur".

A report on "socialist entrepreneurs" reads: "It seems as if ideas and energy are bursting out of them through a previously closed valve!" Generations have been brought up to think of undertakings as a taboo. Sports are, perhaps, the only field where chance, the possibility of undertaking to conquer what seems unconquerable, has remained intact. In the economy and in culture, barriers have been erected from all quarters. Yet, I must confess I could imagine socialism as the very system to give the green light to undertakings; a socialism free of cartels, monopolies and giant multinational enterprises.

Thinking it over, there is nothing sacrilegious in this; all of us are antrepreneurs. Every day is full of possibilities for undertakings; life itself is one enor-ous undertaking. Readiness to experiment, initiate, undertake is a certainly ineradicable human instinct; the forms, stakes, risks and goals his takes are innumerable and highly diversified.

But although this instinct is ineradicable, it may be repressed.

On the other hand, on healthy soil it can be trained, and, in economy, society and culture, can even be rectified to serve public purposes.

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PÁL, GY.: *Imre Kovács wrote: "It can be safely stated, without being romantic, that the chief preserver of our Hungarian identity, both in the past and in the present, was the peasantry, so great pains must be taken to protect the peasantry which forms our ethnic basis; changes*

must be effected in the relevant policy, social structure and economic management, so as to create favourable living conditions. This point of view must be given due consideration when reorganizing agricultural production and carrying out farm reforms." Do the Hungarian peasant and the peasant way of life described by Móricz, Péter Veres, Pál Szabó, Illyés and others still exist in Hungary ?

FEKETE, GY.: If they still exist, they are in the process of disappearing.

Of course, old peasants who still have one foot in the co-operative farm, or are already pensioners, and who continue to do the kind of peasant work learned from their fathers and grandfathers 30—40 years ago, do exist. They are neither willing nor able to change their way of life.

This old peasant way of life has a charm and attraction of its own. It is so closely linked to nature, to the fauna and flora, that it offers a feeling of completeness that no sort of specialized work can offer.

According to a tape-recording I once made, F. V., an old peasant from Orosháza, had the following to say on this subject: "I do not want to be dependent on anybody. I do not want to be responsible to anybody except myself and the Lord . . . Health is the only important thing. I have never felt farm-work to be a burden, not even in bad weather; it was good to feel: I can bear even this. The peasant's life is a state that schools body and soul alike. It is a varied activity, a creative activity. And everything starts afresh each year, and this provides continuous changes so that you can never stop as long as you live. I might almost say, there is no time even to be ill while doing peasant work. The strong belief that everything has to start anew because that is the way of the world, keeps one alive and full of hope up to the end."

The thousand-year-old historical form of life is certainly vanishing, and we do not know yet what will follow it. How much of this way of life, or rather of this feeling for tradition, will be preserved by the millions of gardeners, whom I might well call week-end peasants? And there is no knowing what will be preserved by those who are still full time agricultural workers under circumstances totally different — not only in the co-operative farm but also at home, around the house and in the homeplot — from those experienced by their fathers and grandfathers.

The large number of new houses, the cars which have replaced the carts in the sheds, the modern furniture, labour saving devices, coloured TV-sets and hi-fi sets tell us little about the future, and the part that will be played in it by the peasant legacy. An abrupt change will be needed here if intellectual, emotional and moral demands are to rise to the same level.

I freely admit that his is not a reassuring answer to Imre Kovács's words. The historical role he mentioned was not fully accepted even by the peasantry of the past; still less can it be imposed on the present and future workers of agriculture. Now, under socialism, the legacy of the "preserver of our Hungarian identity", and of the "peasantry which forms our ethnic basis" must be shouldered by the whole nation. At least, it should be.

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PÁL, GY.: *Thank you for the interview.*

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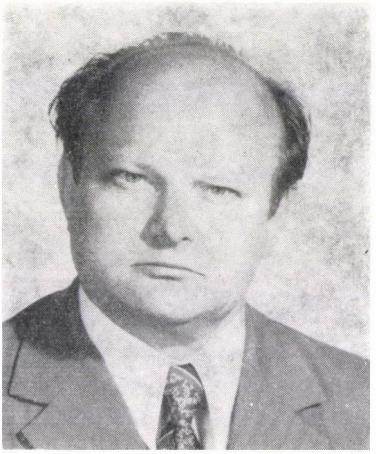
AS I SEE IT . . .



SOCIAL AND ECONOMIC IMPLICATIONS OF AGRICULTURAL DEVELOPMENT IN HUNGARY

Hungarian agriculture can look back upon a successful ten-year period. The dynamic development of agriculture in the last decade created a sound basis for an increase in food production, and, in addition to a favourable domestic food supply, for the expansion of Hungarian food exports.

Since the large-scale reorganization of agriculture was completed, the standard and composition of agricultural production forces have substantially changed, as a response to the social, economic, biological, technical and technological progress made in the meantime. Agriculture, which was previously based mainly on live labour and draught power, is now carried on in increasingly up-to-date, large-scale establishments and is linked in many ways to other sectors of the national economy and to the international market. Its every-day activity and social efficiency is increasingly determined by co-operation with industry, trade and foreign markets, and by a system of mutual production and economic relations.

The role of food production in the national economy is primarily determined by its outstanding importance in domestic consumption and its share in the country's exports. In comparison to other sectors of the national economy, food production still uses less imported material, thus considerably improving the balance of payments.

It has now become evident that agricultural and food products, most of which are easy to market make it possible to transform a considerable amount of other industrial work (machines, fertilizer, pesticides, etc.). Agriculture is almost the only sector where, with the help of photosynthesis and biopotential, the energy input can be multiplied.

The conditions for food production are favourable in Hungary, due not only to natural factors but also to farming experience and to the fact that the food processing capacity is more or less adjusted to the amount of agricultural production.

Besides producing food and basic materials for the food industry farms are taking an increasing part (through subsidiary activities) in industrial co-operations, in producing shortage goods which are important from the point of view of public supply, or in servicing.

Through the extension of their industrial and servicing activities the large-scale farms have promoted the industrialization of the countryside and the employment of the local labour force, have lessened the differences caused by natural economic factors, and, as a result of all this, have increased the technical and cultural standard of the villages.

The reform gradually introduced in agricultural management from the middle of the sixties offered a wider scope for the operation of price and financial regulators and incentives.

The farms became interested in improving the level of management, as the producer's price level rose and part of the net income could be withheld for the purposes of farm development and increasing the extent of personal interest.

The development induced in the first half of the seventies by the possibility for independent management and extended reproduction, and by the increase in personal interest, was even more dynamic than expected. Those involved in the economic and social management of the agricultural enterprises and co-operative farms gave a flexible response to the changes.

It was in this same period that production systems* gained ground, greatly contributing in certain sectors to the provision of the financial, technical, intellectual and organizational conditions required for production and to a rapid increase in yield.

I. The development rate of agricultural production

Agricultural production of Hungary in international comparison

Only 0.15% of the total area used for agricultural purposes in the world is found in Hungary. However, the 71% proportion of the agricultural area within the country is favourable even on a world scale.

As a result of an improvement in the utilization of the available agricultural area, the share of Hungary in the production of the most important agricultural and horticultural crops and in meat production is considerably larger than its territorial proportion.

The dynamic development and favourable changes in the agriculture of Hungary are well reflected by the trend in the production value per hectare of agricultural area (Table 1).

In 1980 the agricultural production value per hectare of agricultural area in Hungary, was over 600 dollars, and in the dynamism and extent of development Hungary exceeded Austria, France and Italy.

In comparison to the agricultural production of Denmark and Holland, on the other hand, Hungary produces hardly more than half of the former, and slightly more than a quarter of the latter, which shows the possibility of further development in Hungary. The difference lies not so much in the specific values of crop production and animal farming as in the intensity of the different production structure (e.g. the floriculture of Holland) or in the livestock density which, however, is based on substantial imports of fodder.

Due to the improved technical and financial situation of the farms, and to the increase in yields and the sharp reduction in the number of those working in agriculture, the agricultural production value per agricultural earner rose more than threefold in Hungary over a period of twenty years and exceeded 4000 dollars in 1980. As regards the production value per agricultural worker, Hungary is still far behind the developed capitalist countries in spite of the considerable progress recently made. However, if only those agricultural earners engaged in crop production and livestock farming, who today represent a mere 60% of the workers on large-scale farms, were taken as the basis of comparison, then one agricultural earner would be found to produced the basic foodstuffs for some 20 persons in Hungary, which comes close to the level of European countries with developed agricultures.

On the other hand, successful progress in several branches of agriculture is reflected by the fact that, with regard to per capita cereal and meat production, Hungary has caught up with the leading countries of the world.

With its 1400 kg per capita cereal production and 140 kg per capita meat production Hungary is now in the vanguard of world production. The per capita meat production of Hungary is more than four times the world average and twice as much as the average in the COMECON countries. At the same time, the standard and economic efficiency of the production of roughage crops and certain vegetables lag behind to a greater or lesser extent by international standards.

Increase in the gross and net production of agriculture

Agriculture is still one of the most important sectors of the national economy. In spite of the present unfavourable price ratios, due to the low income content, agriculture supplies 17.5% of the gross national product and 17.2% of the net national product. It has an 11%

* Organizations supplying complex services within a certain sector. In return for a share of the surplus yield, or on payment of servicing fees, they supply or loan seed, machinery and materials, and provide the farms with expert advice and training.

Table 1

*Agricultural production value per hectare of agricultural area**

Country	Average for				Index: 1976–1980 / 1961–1965, %
	1961–1965	1966–1970	1971–1975	1976–1980	
Socialist countries					
East Germany	565	664	776	840	148.7
Poland	446	515	581	603	135.2
Czechoslovakia	394	472	544	582	147.7
Hungary	346	370	452	573	165.6
Bulgaria	312	383	408	456	146.2
Romania	215	258	313	412	191.6
Yugoslavia	202	244	280	334	165.3
Soviet Union	76	91	116	125	148.7
Capitalist countries					
Holland	1231	1456	1930	2305	187.2
Denmark	860	899	928	1108	128.8
West Germany	729	827	896	965	132.4
France	399	460	507	558	140.8
Austria	396	454	469	524	132.3
Italy	373	412	518	567	152.0
USA	135	151	170	190	140.7

* Calculated in US dollars on the basis of 42 products, at average producer's prices for 1971—1975.

Table 2

Average increase in the gross agricultural product

Year	Total	Crop production	Livestock farming
1961—1965	1.2	0.2	2.5
1966—1970	2.8	1.9	3.9
1971—1975	4.6	5.6	3.5
1976—1980	2.5	1.7	3.4

share in the stock of fixed assets, and 19% of the total number of active earners in Hungary are employed in agriculture.

The importance of this sector appears in a different light when its growth rate is taken into consideration. As a result of considerable technical progress the increase in the gross production value accelerated in the first half of the seventies, and the growth rate became similar to the development rate of the national economy (Table 2).

It is noteworthy that in the past decade the growth rate of the large-scale farms exceeded that of both the food industry and the national economy, which indicates the possibilities hidden in industrialized agriculture. Thus, with a sound agricultural policy, if up-to-date materials and implements are made available, agriculture could be developed efficiently and rapidly as an integral part of the national economy. However, the data series from the period after 1975 reveal a decrease in the rate of development, in accordance with the change in the world situation.

On the other hand, the increase in agricultural production involved financial inputs and fixed assets investments increasing from year to year. In the period under discussion the material costs in this sector rose by 60%, while the energy consumption and fixed assets increased more than twofold. In accordance with this, the costs of fuel, pesticides, building and machine maintenance and amortization increased at a particularly fast rate. At the same time, the agricultural production area decreased by 250 thousand ha (3.6%) and the number of those employed in agriculture by 200 thousand (17%). Thus, most of the increase in the stock of assets and the financial inputs went to compensate for the loss of production area and live labour.

The growth rate in the net agricultural product lagged behind the gross production. This less favourable trend in the net production value can be explained partly by the change in the production structure, since livestock farming requires more assets and materials and has a lower net income content than crop production. At present the net income content of the production value is 22% in livestock farming and 52% in crop production. And within crop production, the production of cereal crops is increasing more rapidly than that of more labour-intensive crops with higher net contents.

In the large-scale farms the improved ratio of labour-intensive and profitable subsidiary activities may stabilize the level of net production to some extent in the future. This is indicated by the fact that in the last two years the number of people working in large-scale farms has risen by some fifty thousand.

However, the increasing number of staff are employed in industrial plants rather than in agriculture itself. In modern large-scale farming there is a continual release of the internal labour force, which can only be employed by extending the industrial activity.

The proportion of net production is invariably the highes in small-scale production based on a limited stock of assets and a large proportion of manual labour. The utilization of assets and materials is, however, increasing in the small farms too, so a further decrease in the ratio of net production can be expected in this sector as well.

Precisely because of its larger share in the production of labour-intensive crops, small-scale production supplies 32% of the gross agricultural product and nearly 50% of the net agricultural product even today. It is worth mentioning here that nearly the same number of working hours are used now in small-scale production as in the largescale farms altogether. The share of small-scale farms is thus even more decisive in producing national income than in commodity production, since, through the useful employment of labour, it contributes to maintaining the level of real income and is thus an important factor in the national economy.

II. Changes in the production structure of agriculture

The development of agricultural production has been accompanied by considerable changes in the production structure.

The production structure of the large-scale farms was principally influenced by the difference in growth rate between the basic activity and the secondary activities.

In the sixties and even at the beginning of the seventies a large proportion of the agricultural labour released in consequence of the introduction of modern technologies was absorbed by industry. Later this labour migration was reduced to a minimum or stopped altogether, because the ever widening processing, subsidiary industrial, servicing and marketing activities of the large-scale farms meant that they were able to provide their workers with working conditions and incomes similar to those in industry.

One of the present characteristic features of development in the large-scale farms is the more rapid growth of the industrial and servicing activities compared to the production of agricultural basic materials. Besides the high demands raised by the national economy, this is justified by the economic efficiency of transferring labour intensive activities to the country, the advantages of employing the labour force released from agriculture on the spot, and the necessity for more flexible management of the agricultural enterprises. It should be mentioned that the activities which provide services to agriculture, such as the building industry, food processing, machine repair, trade and servicing activities, partly evolved

Table 3

Gross production structure of farms

Designation	1960	1970	1980
Gross production	100.0	100.0	100.0
including			
agricultural crops	96.0	82.1	72.5
agricultural services	0.7	2.5	7.1
other industrial or construction activities	3.3	15.4	20.4

within the large-scale farms, mostly through the retraining of workers released from agriculture. This tendency is reflected by the trend in the gross production of the farms, shown in Table 3.

The production value of activities other than farming has considerably increased over the past 20 years, and their share in the total production has risen to 27.5%. Still greater is the shift in proportions in the sales returns of large-scale farms; in 1980 39% of the sales returns on state farms and 42% of that on co-operative farms came from activities other than farming. The production on small farms, on the other hand, is still confined to the basic activity.

Among the subsidiary activities, the proportion of food processing and particularly of the other industrial activities has risen, while that of the building industry and marketing has decreased.

Changes in the structure of agricultural activity

In the 20-year period in question the structure of agricultural activity also changed. The establishment of large-scale farms and the development of the production forces chiefly promoted the production of cereal crops. The structure of production shifted towards a vertical system of cereal and meat production, both for domestic consumption and for export.

Table 4 shows the changes in the gross agricultural product.

The data in the table indicate a process of intensification in the production structure of agriculture.

Within the production structure vegetable and fruit (particularly apple) production and livestock farming significantly increased in importance. It is worth mentioning that while field crop production as a whole is decreasing, the production of cereal crops is dynamically developing, now making up around two thirds of the total, while the reduction has mostly occurred in the production of roughage crops and of labour-intensive industrial crops (tobacco, potatoes, sugar-beet).

In livestock farming the proportions of pig and poultry rearing have increased at a particularly fast rate.

The data in the table allow a sectoral analysis to be made of the production structure.

Livestock farming and plantation crops thus play a more important role in the production structure of state farms and small farms, while in co-operative farms field crop production (in particular cereal production) has remained predominant.

In cattle farming the importance of large-scale farms is increasing, while in pig farming small-scale production (with a share of more than 50%) still has a decisive role.

Small-scale livestock farming cannot be evaluated without considering the fact that the fodder and part of the breeding stock are produced by the large-scale farms, which also organize most of the marketing. This is particularly so in the co-operative farms, and partly explains the smaller number of livestock and the greater integration of the co-operative farms. This is one way in which the volume and economic efficiency of production can be increased even in the long run without any considerable investment or an increase in the number of staff.

In the course of farm development the system concept has come into prominence, which means that sectors which are biologically, technically or economically more favourable are developed more rapidly, since the concept of a complex system, where biological, chemical,

Table 4

Distribution of gross production value, %

Designation	State farms, combinates	Co-operative farms		Subsidiary and private farms	Agriculture altogether
		collective farms	homeplots		
	1960				
Gross production value	100.0	100.0	100.0	100.0	100.0
Crop production and horticulture	59.5	80.8	34.6	58.1	60.8
field crops	50.5	73.5	24.2	38.7	47.9
vegetables	—	0.3	1.8	4.5	2.1
fruit	2.4	1.9	3.5	4.8	3.3
grapes	4.8	2.2	5.1	8.8	5.4
Livestock farming	40.5	19.2	65.4	41.9	39.2
cattle	20.0	9.5	24.2	9.8	13.7
pigs	13.4	7.4	21.8	15.5	14.2
sheep	3.5	1.5	1.0	0.4	1.2
poultry	2.3	0.8	17.9	15.1	9.5
	1980				
Gross production value	100.0	100.0	100.0	100.0	100.0
Crop production and horticulture	47.1	60.4	34.0	38.2	50.4
field crops	29.1	49.2	12.3	14.0	33.5
vegetables	1.3	3.9	9.4	8.6	5.2
fruit	5.9	3.1	6.5	9.3	5.1
grapes	9.5	2.8	5.7	6.0	5.6
Livestock farming	52.9	39.6	66.0	61.8	49.6
cattle	15.4	16.0	16.5	7.4	14.2
pigs	20.9	10.4	30.4	30.0	18.7
sheep	2.2	3.5	1.6	1.5	2.6
poultry	11.3	9.5	15.1	17.7	12.1

technical and economical conditions are co-ordinated, is gaining ground in farm development. It is a well-known fact that in any sector of the national economy, and this applies to various branches of farming too, a sudden change in quality can only take place if a complex system of conditions is simultaneously met. In Hungary the setting up of large-scale farms fortunately coincided with the appearance of highly productive wheat varieties, the utilization of Soviet, Czechoslovakian and East German machinery which was then some of the best in the world, and, in addition, with the establishment of favourable economic conditions for cereal production.

In Hungary complex sectoral development was first put into practice in wheat production. It should be emphasized that the biological potential was provided by high-yielding Soviet wheat varieties and the technology by Soviet and Czechoslovakian machinery, while the conditions required for a high rate of fertilization were created partly through domestic

production (nitrogen) and partly from socialist imports (superphosphate, potassium). A substantial rise in the purchase prices of cereals and the cancellation of plan obligations also promoted the development of production. It thus became possible to export considerable amounts of cereals over the last 15 years in place of the cereal imports which were required before 1964.

As for wheat, the system-oriented development of production was carried out in poultry farming, and later in maize and pig production as well.

Since the beginning of the seventies a rapid increase in the volume of milk production has been achieved by means of an appropriate change in breed. The trends in total yields and yield averages for the major agricultural crops are shown in Table 5.

The data in the table reveal that both the yields and yield averages for wheat and maize were multiplied in the period concerned, and today the production level in these sectors equals or at least approaches that of the most developed countries. The 6.84 ton national maize yield average achieved in 1982 is particularly noteworthy; the yield averages of many farms have exceeded 10 tons/year for many years.

Table 5

Total yields and yield averages for major field crops

	1960	1965	1970	1975	1980	1980 figures expressed as a percentage of the 1960 figures
Wheat						
total, 1000 t	1.768	2.443	2.718	4.005	6.068	343.2
average, q/ha	16.8	21.7	21.3	32.0	47.6	283.3
Maize						
total, 1000 t	3.504	3.564	4.013	7.088	6.535	186.5
average, q/ha	25.0	29.3	33.8	50.2	53.2	212.8
Sunflower						
total, 1000 t	68	75	92	154	454	667.6
average, q/ha	9.7	7.9	10.1	11.9	16.6	171.1
Sugar-beet						
total, 1000 t	3.370	3.452	2.174	4.089	3.928	116.6
average, q/ha	253.3	286.4	287.3	322.2	376.4	148.6
Potatoes						
total, 1000 t	2.656	1.435	1.430	1.268	941	35.4
average, q/ha	105.1	71.9	104.1	126.4	149.6	142.3
Tomatoes						
total, 1000 t	202	242	247	263	354	175.
average, q/ha	147.2	151.6	164.5	180.3	233.1	158.4
Green peppers						
total, 1000 t	83	104	104	112	80	96.4
average, q/ha	133.9	121.8	101.2	130.2	105.7	78.9

At the same time it can also be seen that particularly for vegetable crops with high requirements of manual labour and assets, Hungary is far below the international level, as regards both total yields and yield averages.

The trend of yield has been plotted in order to give a clearer picture of the changes in the production of the different sectors (Fig. 1).

The higher rate of development in the seventies was connected with greater investments and with the increased import of technologies that made a high level of up-to-date

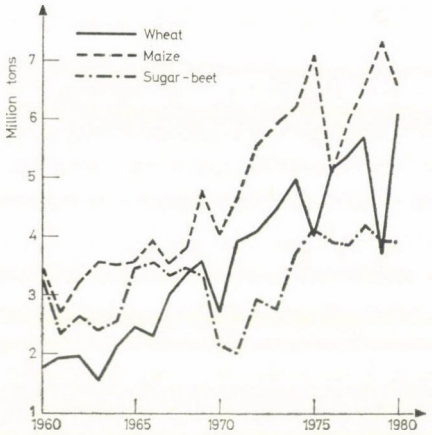


Fig. 1. Yields of major field crops

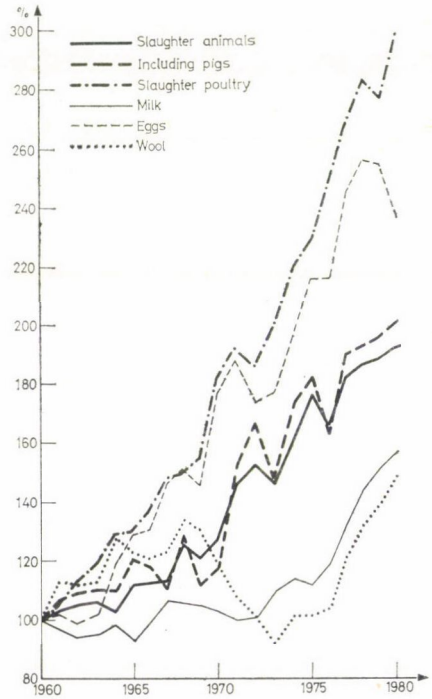


Fig. 2. Animal products

Table 6

Trends in the animal stock and the production of animal products*

Year	Cattle stock 1000 animals	Slaughter cattle 1000 tons	Milk produced million litres	Pig stock 1000 animals	Slaughter pigs 1000 tons	Sheep stock 1000 animals	Slaughter sheep 1000 tons	Wool tons	Poultry stock** million animals	Slaughter poultry 1000 tons	Eggs million
1960	1.963	250	1.570	6.388	586	2.250	19	8.175	26.844	154	1.848
1965	1.919	258	1.465	6.590	703	2.460	30	10.060	29.209	201	2.393
1970	1.911	324	1.631	7.311	691	2.316	37	9.776	35.097	281	3.280
1975	1.904	379	1.767	6.953	1.072	2.039	35	8.393	38.667	355	4.001
1980	1.918	329	2.471	8.330	1.178	3.090	42	12.143	42.764	464	4.385
1980/1960, %	97.7	131.6	157.4	130.4	201.0	137.3	221.1	148.5	159.3	301.3	237.3

* As of 31st December. ** 1960—1970: breeding stock, from 1975: mature stock.

Table 7

Yield, land quality and cost-income relations on the basis of the 1980 data for maize production on co-operative farms

Designation	Yield average groups (t/ha)						
	below 3.00	3.01—4.00	4.01—5.00	5.01—6.00	6.01—7.00	7.01—8.00	above 8.00
Co-operative farms	189	132	208	283	218	127	56
Total sowing area, ha	56,206	56,233	115,482	185,482	181,648	114,616	51,623
Average sowing area per farm, ha	297	426	555	657	833	902	922
Average gold crown value,* gold crowns/ha	13.61	16.02	19.24	22.52	24.34	29.21	31.58
Yield average, kg/ha	1,857	3,576	4,526	5,532	6,429	7,396	8,513
Production costs, Ft/ha	9,690	13,616	15,110	16,262	17,014	18,397	20,254
Production value, Ft/ha	5,878	11,277	14,120	17,261	20,034	22,817	26,546
Income, Ft/ha	—3,812	—2,339	—990	999	3,020	4,420	6,291
Profitability,** Ft/100 Ft	—39.34	—17.18	—6.55	6.14	17.75	24.03	31.07

* Index of land quality. ** Income per 100 Ft production costs.

production possible. However, yield fluctuations also call attention to the importance of meteorological factors.

The favourable change in the volume of animal products primarily indicates the rapid development in the fodder-consuming branches, i.e. pig and poultry farming and egg production.

The improvement in milk production in the second half of the seventies also deserves attention. This is illustrated by data on the number of animals and the volume of animal products (Table 6).

The greatest results achieved in the course of the last 20 years due to the system-oriented view of development were obtained in egg, poultry and pork production.

In these sectors the output grew at a rate far exceeding the increase in staff number, indicating that progress was determined primarily by qualitative development.

It is also noteworthy that the substantial increase in milk and meat production was achieved with a decreasing number of cattle. Still more striking is the development of pig, theep and poultry farming, where in comparison to a 30, 37 and 59% increase in the number of animals the production of slaughter animals grew by 100, 121 and 201%, respectively.

The development dynamics and fluctuation in the production of animal products are shown in Fig. 2.

As indicated by the graph, the acceleration of development in poultry farming began in the mid-sixties, in pig farming at the beginning of the seventies and in cattle and sheep production in the mid-seventies.

A survey of the system of conditions for development in the different sectors reveals that, assuming optimum biological potential, the assets and manual labour requirements are most favourable in the rapidly developing sunflower and cereal production, and in the fodder-consuming sectors.

The production value per 100 Ft fixed assets in 1980, for example, was 149 Ft for sunflower, 140 Ft for broiler chickens, 115 Ft for wheat, 97 Ft for pigs for slaughter, 92 Ft for maize, 85 Ft for milk, 55 Ft for apples and 29 Ft for grape production.

The live labour productivity is also the most favourable in sectors which are expanding at a fast rate, and least favourable in vegetable and fruit production and cattle farming.

As regards the income level, this tendency did not assert itself in every case.

Although on the basis of world market prices a more favourable income level for the producers could most easily be ensured in cereal production, due partly to domestic demands (milk) and partly to earlier international agreements (exports of vegetables and conserves), the production and export levels of these crops, which are less economically produced, have been maintained artificially, by means of considerable state subsidies.

A better adjustment to world market prices, if it were felt directly by the producers, would certainly promote and accelerate a favourable change of structure. A further increase in cereal and meat production, a decrease in vegetable and plantation crops and a stagnation in cattle farming can thus be expected in the future.

This is in accordance not only with international judgements of value, but also with the possibilities available for exploiting biological, technical and chemical potentials. At present the greatest biological resources are undoubtedly to be found in cereal crops, but the technical standard, the economic efficiency and the farm experience are also the most favourable in this sector.

From the point of view of development, on the other hand, it is also important to make use of the experience obtained in livestock farming, since there is a sound biological basis, particularly in the case of poultry and pigs, and an up-to-date technical standard has also been achieved in this sector.

As world market prices develop and, in the long run, as consumer demands increase, the price situation of meat will certainly improve, as will the competitiveness of Hungary. At the same time, the economic efficiency on the domestic and world markets of vegetable and fruit production, which is still based mostly on cheap manual labour and favourable natural conditions, is getting worse; therefore, in these sectors the provision of domestic requirements is the only realistic objective.

III. Efficiency of farm development

The growth of agricultural production in the period under consideration was associatee with a sharp reduction in the cultivation area and labour force and a great increase in thh utilization of materials and assets. The increase in the value of the latter exceeded the growtd of agricultural production (i.e. the yields of crop production and livestock farming). Con-

sequently, the specific material and assets utilization of agricultural production became higher. The cultivation area and the manual labour, which is still very cheap, could only be replaced by means of expensive implements and industrial materials. Up-to-date large-scale farms were not fully developed until the late sixties or early seventies, so the efficiency analyses are confined to the seventies.

The price of the up-to-date farm implements used more and more widely in agriculture is too high compared to the growth attained in production. Thus, in the period under consideration every 1% reduction in working time input involved a 1.5% increase in fixed assets and a 1.3% increase in investments. Although the output of the farms showed a marked increase, nevertheless, for the above reasons, the total quantity, and particularly the total value, of manual and mechanized labour required per unit product did not decrease but increased.

The role of prices could, therefore, not be left out of consideration in the efficiency analyses either, since the higher price level of industrial machinery and materials and the lower price level of fresh and processed foods, as well as the further increase in price disparity in the second half of the seventies, make it extremely difficult to study the efficiency on the basis of value or income.

The decline in the efficiency of productive utilization in agriculture was contributed to by the fact that in the first half of the seventies the amalgamation of farms was carried out at a faster than optimum rate, unjustifiably expensive investments were made and supplementary costs had to be met. The necessary farm experience, that can only be obtained and properly utilized after several years of operation, could not keep up with the rapidly growing technical and material basis. The economic efficiency was adversely affected particularly by the initial teething problems of the big livestock plants. The increased accent on animal hygiene, the observance of administrative measures and the improvement in social conditions all acted as cost-increasing factors.

The growing proportion of more expensive farm implements of industrial origin increased the costs of farm production. The technological development of crop production involved a complete change of technology. The traditional farm implements were replaced by high capacity special machines and machine systems. At the same time the new production processes demanded an ever increasing consumption of energy. The ever wider adoption of improved technologies resulted in a steady growth in the amount of relatively expensive machinery and equipment and in the amount of industrial materials. The prices of the modern machinery and energy sources, most of which were imported, were very high compared to those of the traditional means they replaced; therefore, the increase in the proportion of these was sufficient in itself to increase the material and assets intensity of farm production.

Thus, in Hungary relatively "cheap" manual labour was replaced by expensive implements. Mechanization was in a large part a social question too, since hard physical work had to be mechanized even when it was less economical for the farm; otherwise the labour force would have migrated, or production could not have been increased at a fast enough rate at the traditional technical level.

The nearly 30% increase in the material consumption of crop production was equal to the surplus of gross production, so the net production hardly changed. True, the unfavourable years of 1976 and 1979 also played some role in this.

The efficiency of material consumption was more favourable over the last five years in livestock farming than in crop production. Besides a 21.5% increase in productive consumption, the gross production value rose by 20%; moreover, over the last 3 years its rate exceeded that of productive consumption. Efficiency thus shows an improving tendency, indicating a parallel rise in the standard of farm management. However, in this case the higher rate of development in the more efficient, fodder-consuming poultry and pig farming, as well as the rapid increase in the producer's price of animal products must also be taken into consideration.

The production structure necessarily shifted towards the material-intensive branches. The faster development of livestock farming compared to crop production, which is relatively less material-intensive, and the consequent change in the ratio of the main sectors, increased the material intensity per unit agricultural production by about 1%. This is due to the fact that materials make up 70% of the costs of livestock farming and only 48% of the costs of crop production.

The efficiency of material consumption was also lessened by the fact that the relatively low energy and material prices encouraged the exaggerated introduction of energy- and material-intensive technologies. In addition, the moral and financial incentives also induced the farms to increase the quantity rather than the quality. It is only over the last few years that economic efficiency has become a key question of farm management.

Relationship between land quality and yield

Within the possibilities available, the farms shape their production structures so as to use the best soils to grow crops which are either highly responsive to land quality, or which could only be grown on poor soils at a considerable loss, if at all. Consequently, the economic regulation system, and in particular the price system, has an influence on the choice of soil for a given produce.

Crops providing relatively high incomes (wheat, maize, sugar-beet, sunflower) are grown on good and bad quality lands alike.

This can be explained by the fact that these crops are less sensitive to climatic and soil conditions, and, due to their relatively favourable income position, they can be economically cultivated even on lands of lower than average quality.

For other crops, on the other hand, the inputs will only be returned if they are produced on better than average lands. It is thus quite natural that these crops are grown on soils with above-average quality. That is why a decisive proportion of the onions, tomatoes, green peas, green peppers and red peppers are produced on good quality lands. On lands of relatively high quality yields and incomes can be increased fairly well by means of supplementary inputs. Another conclusion that can be drawn from the data, however, is that on poor soils and at low yield levels even maize can only be produced at a loss (Table 7).

With an increase in the maize yield average the production costs per unit product also decrease. While the production costs of 1 ton of maize are 5,200 Ft below an average yield of 3 ton/ha, at a specific yield of over 8 ton/ha this figure is 2,400 Ft. However, the hyperbola type of correlation analysis calls attention to the fact that at a higher level of management a further reduction in production costs can only be achieved under definite conditions and requires greater and greater efforts.

Trend of yields per unit area

The yields per unit area form one of the most important efficiency indices of agricultural production. To increase yield levels becomes more and more important at a time when the cultivation area is decreasing. The development achieved in recent years, the introduction of up-to-date varieties and the change in the standard of chemical materials and technical facilities have led to a considerable increase in specific yields, as shown in the previous tables.

Not only the trends in crop production yields, but also the vertical relations of the farms are expressed by the changes in the gross and net values of production per unit area.

Table 8

Trends in gross and net production value per ha

Designation	1970	1975	1980	Index: 1980/1970
	1000 Ft/ha*			%
Gross production value				
Total agriculture	22.1	29.1	35.7	161.5
of which:				
state farms	24.6	32.9	53.6	217.9
co-operative farms	16.6	22.2	27.1	163.3
Net production value				
Total agriculture	9.8	11.4	12.6	128.6
of which:				
state farms	6.0	9.1	12.2	203.3
co-operative farms	6.2	7.3	8.6	138.7

* At 1976 prices.

Table 9

Productive consumption of materials of agricultural and non-agricultural origin

Designation	1970	1975	1980	Index: 1980/1970
	million Ft			%
Agricultural origin	34.156	39.130	41.013	120.1
Non-agricultural origin	35.931	57.109	71.732	199.6
Total productive material consumption	70.087	96.239	112.745	160.9

A number of conclusions can be drawn from Table 8 which shows the trend in gross and net production value per ha.

First of all a rapid rise can be seen in the gross and net production value of large-scale farms; the growth rate for state farms is particularly outstanding.

The difference in growth rate between the two five-year cycles is noteworthy. In the co-operative farms the rate of growth was considerable at the beginning and decidedly lessened in the second half of the decade. The growth rate for state farms, on the other hand, was more vigorous in the second half of the decade.

A further fact indicated by the national and sectoral averages is that net production per ha is the highest in the small farms even today, due to their large share in the production of manual labour-intensive crops.

Recovery of financial inputs

The present industrialization and modernization of agriculture means, among other things, that an increasing proportion of the costs is represented by various materials of non-agricultural origin. This process is clearly seen from the data in Table 9.

The data in the table reveal that between 1970 and 1980 the productive utilization of materials of agricultural origin grew only slightly, while that of non-agricultural materials increased many times. Consequently, the proportion of materials of non-agricultural origin within the total productive utilization rose to 64%. This change is still more conspicuous in large-scale production; in the state farms this proportion is 70%, and in the co-operative farms it is over 60%. With an increase in commodity production the consumption of industrial materials rises rapidly in small-scale production as well. The increasing consumption of materials and implements of industrial origin suggests that the results, economic efficiency, and cost and income trends of agricultural production are becoming more and more dependent on the quality, purchase price and effective use of materials and farm inplements of industrial origin.

Trend of labour productivity

The trend of labour productivity is the most important parameter of any society or sector, as it reflects the financial basis and stock of assets of the production as well as the organic composition of the capital. However, although Hungarian agriculture can already be said to be up-to-date it still employs a great deal of live labour, and apart from the yield level attained in different sectors, it is in labour productivity that Hungary is farthest behind the developed countries.

Over the last 20 years great progress has been made in labour productivity. The reduction in the number of agricultural earners and the technical improvement of production has gained expression in the rapid increase in labour productivity.

As seen from the data in Table 10, the per capita gross production value increased more than twofold for Hungarian agriculture as a whole, and at a still higher rate on the large-scale farms.

However, on the best farms and sectors the labour productivity is much higher than this. In 1981, for example, there were three large-scale farms, including one co-operative farm, where the gross production value exceeded 1 million Ft per worker, and in some sectors it was over 2 million Ft.

Table 10

Gross and net production value per capita

Designation	1970	1975	1980	Index: 1980/1970
	thousand Ft/capita*			%
Gross production value				
Total agriculture	132.5	200.1	254.3	191.9
of which:				
state farms	160.1	223.3	384.8	240.4
co-operative farms	110.6	183.4	242.6	219.4
Net production value				
Total agriculture	58.7	78.5	90.0	153.3
of which:				
state farms	39.1	61.6	87.8	224.6
co-operative farms	41.5	60.8	77.5	186.8

* At unadjusted 1976 prices.

Table 11

Trend of labour per unit product, hours/100 kg

Designation	1971	1975	1979
Wheat	3.28	2.85	2.53
Maize	6.26	2.29	1.61
Sugar-beet	2.88	1.43	0.89
Sunflower	10.60	9.02	4.95
Alfalfa	2.82	1.90	1.21
Potatoes	6.62	5.27	4.36
Onions	9.61	7.18	7.02
Green peppers	19.56	16.56	16.05
Tomatoes	6.54	8.15	3.94
Apples	14.92	11.04	8.75
Grapes	32.93	23.41	15.08

It is noteworthy that net production also increased more rapidly in the large-scale farms. The rate of increase was higher in the first period, while in the second period industrial materials and implements were the main sources of an increase in production. The increasing material consumption of small-scale production is indicated by the lower growth rate in the national net production average. In spite of this the net production value on small-scale farms is still higher than the spcific values for large-scale farms, which shows that in labour-intensive sectors the proportion of small-scale production continues to be larger.

The trend of labour productivity varied from sector to sector, as shown by the change in manual labour input per unit product. The trend of total labour consumed per unit product according to the data of 300 co-operative farms is seen in Table 11.

The decrease in labour intensity was most strongly felt in cereal and industrial crop production, where the technological development was the most dynamic in the period concerned.

The data in the table also indicate considerable time-lags between the technical changes in different sectors. In sectors where mechanization was still at an initial stage, and the anyway high manual labour requirement of the harvest was increased by a larger yield and a market demand for processed goods, the specific labour demand did not decrease but sometimes even increased (for example in the case of green peppers). There are, however, fewer such sectors on the farms each year (green peppers, raspberries, currants), and the manual labour demands generally cannot be covered by the labour capacity of the farm itself. These sectors can only be retained on large-scale farms by increasing the financial interest in some form of sharing in the final product. Recently an economical division of labour has developed in large-scale vegetable and fruit production too. The large-scale farm accomplishes the easily mechanizable work-phases (soil cultivation, planting, plant tending), while the manual labour-intensive phases (pruning, picking, etc.) are carried out in the form of share cultivation. Marketing, of course, is organized by the large-scale farm, so the share-workers receive their share from the sales returns.

When manual labour was first substituted by machinery the replacement of hard physical work was the principal consideration while the economic aspect of one process was less important. The latter only came into prominence when some change took place in the technology: when cultivation based on manual labour was replaced by an up-to-date mechanical procedure.

Looking back over the past period it is now quite obvious that in some crop production sectors, and particularly in livestock farming, this process was not always satisfactorily carried out. In some cases the replacement of labour by machinery was accelerated for no apparent reason irrespective of the existing conditions. The motive was the social demand to eliminate hard physical work rather than economic considerations.

Fixed assets efficiency in agriculture

Agricultural production is becoming more and more assets-intensive. In the United States of America fixed assets of about 2.5—3 dollars in value are used for the production of agricultural goods with a value of 1 dollar. In the small and medium-sized farms of the highly mechanized, developed countries of Western Europe this ratio is four- to fivefold.

Table 12

Efficiency of fixed assets on the basis of gross and net production value per 100 Ft of fixed assets

Designation	1970	1975	1980	Index: 1980/1970
	Ft/100 Ft fixed assets*			%
Gross production value				
Total agriculture	94.0	82.0	74.3	79.0
of which:				
state farms	61.4	57.4	67.9	110.6
co-operative farms	105.2	81.6	72.5	68.9
Net production value				
Total agriculture	41.6	32.2	26.3	63.2
of which:				
state farms	15.0	15.8	15.5	103.3
co-operative farms	39.5	27.0	23.2	58.7

* At unadjusted 1976 prices.

The assets intensity index of Hungarian agriculture is much more favourable than this, since the value of assets per 1 Ft production value is 1 Ft on a national scale, 1.20 Ft in the co-operative farms and 1.33 Ft in the state farms. But there are many large-scale farms in Hungary where the specific fixed assets demand is below 1 Ft.

The efficiency of fixed assets, at unchanged prices, showed a considerable decline over the last 10 years. However, the whole of the decrease per unit of fixed assets occurred in the early part of this period, when large-scale production was being set up, while in the second half of the period discussed some improvement was shown in the state farms.

With the help of Table 12 an opposing trend in the efficiency indices of fixed assets can also be traced.

In the second half of the seventies the state farms raised their management standards due to the better exploitation of earlier investments, mainly in improvement in their processing activities (alfalfa meal production, fodder mixing, wine-making), while the co-operative farms were still in the phase of large investments, though some improvement in their management level prevented a further decline in assets efficiency. The recent more rational management, and the success achieved in 1982 in particular, further improved the indices of assets exploitation.

As for the efficiency measured by net production, the tendencies are again divergent. The lack of synchronization is apparent here, too. In the state farms the technical modernization was considerably advanced by the second half of the sixties, so the amount of labour employed became stabilized in the seventies. In agriculture, and in the national economy as a whole, a substantial reduction in the working force occurred at the beginning of the seventies (partly through retirement), so in the second half of the decade the ratio of net production changed to a lesser extent.

On evaluating the efficiency of fixed assets in the light of the above parameters, there seems to be some justification for the reduction, since part of the fixed assets increment made up for the loss of live labour and increased the productivity of the remaining labour force. This is confirmed by the fact that during the last 10 years the proportion of machinery investments was considerably larger than in the previous period. Thus, mechanization serves in a large part to replace manual labour, and this too decreases the proportion of net production.

The advantages of up-to-date implements were felt to the greatest extent in crop production, where yields also increase at a faster rate due to the better coordination of biological, chemical, technical and economic factors. More serious problems were encountered in economically establishing the conditions required for concentrated large-scale livestock farming, since the increase in yields in this sector did not keep pace with the expensive inputs, and the establishment of economical farming conditions also took longer.

Some of the building investments, particularly in the second half of the decade, served through the agency of additional investments, to complete the existing production capacity. An improvement in social welfare and an increase in communal investments also took place during this period. All this only increased the production capacity slightly, if at all; it was mainly working conditions and social circumstances that were altered for the better.

The decrease in efficiency was partly due to factors that can mostly be eliminated in the course of subsequent investments. For example, some of the production capacity established at the end of the sixties and the beginning of the seventies did not meet the requirements, owing to problems in organization and lack of practical experience. Therefore, they had to be modernized before they were worn out.

IV. Major lessons of agricultural development

Today, after a longer period of experience, it can be established that the agricultural policy of Hungary made a correct assessment of the economic, social and political importance of agricultural production. It created the necessary political, organization and financial conditions for the development of this sector of the national economy, successfully adapted itself to the economic and social changes that ensued in the meantime, and ensured dynamic development, thus providing a satisfactory domestic food supply and an increase in food exports.

The socialist reorganization of agriculture was justified by the fact that in the middle of the sixties production, particularly cereal production, already far exceeded the earlier level of the small peasant farms; the use of up-to-date production implements and methods applied has convinced everybody of the advantages of large-scale farm management.

In the middle of the seventies, when the explosion of world market prices, particularly for energy, made it quite clear that the economic situation would become more and more

difficult, a change in the agricultural policy became necessary. Agriculture reacted to the difficulties in two ways. On the one hand, the development of the most important products was promoted by the use of up-to-date varieties and machinery; on the other hand, the labour- and investment-intensive sectors which were not easy to fit in to the framework of the large-scale farms were transferred to homeplots or to small-scale farms, whereby farming was given a wider social basis and the pressure was taken off the large-scale farms.

The last decade also brought considerable changes as regards the regional location of farming. As opposed to the earlier concepts and practice, where vegetable and milk production, which require considerable transport capacity, were located near the market, the proportion of these sectors decreased in the environs of cities and industrial centres, and the readily mechanized branches of crop production and livestock farming, and particularly the industrial and servicing activities, became predominant in the production structure, while the production of labour-intensive crops was transferred to areas where a larger labour force was available.

The development, which was outstanding even on an international scale, was associated, however, with a simultaneous differentiation in production structure and between the farms. Therefore, the ratio of easily mechanized sectors with a favourable biological background, such as cereal and industrial crops, poultry, pork and egg production, have rapidly grown within the production structure, while vegetable, fruit and cattle production can only be maintained with substantial state subsidies.

It is mostly in farms with favourable natural and economic conditions that the production has grown, while in those with unfavourable conditions, which occupy one-third of the production area, it is stagnating.

Consequently, the differentiation between the farms has greatly increased. In farms with favourable conditions the management level, farming efficiency, income level and development potential far exceed the average, while in those with unfavourable conditions the corresponding parameters are much lower in spite of substantial (some 20—25%) state subsidies, and often even simple reproduction runs into difficulties.

It is a generally recognized fact that the organizational diversity of production, where the farms complement or even complete with one another, is a long-range factor of economical production and the assertion of social interests. The large-scale farms, with the help of various forms of co-operation, cover the full vertical system of production, processing, purchase and marketing to an ever greater extent, thus ensuring a high level of production and management and facilitating a rapid adaptation to market demands.

The co-operation between various sectors in the course of production was also established in the last decade. By means of a division of labour, crop production, carried out on large areas with modern facilities, and certain branches of livestock farming have been concentrated in the large-scale farms under economical conditions, while small farms still play an important role in the production of labour-intensive crops. The small farms mostly work with simpler and cheaper fixed assets, but it must not be forgotten that the stock of assets of the large-scale farms which integrate them are also of indirect or direct service to small-scale producers (e.g. transport).

The socio-economic division of labour achieved through the integration of large-scale farms (supply of fodder and breeding stock, servicing and marketing activities) is an economical formula highly advantageous for the national economy, planned to be maintained for the long term.

The independence of individual farms and the expansion of personal interest are still fundamental pillars of the economic policy. Without such concepts, the rapid farm and social development that has raised the standard of some Hungarian farm products to world level could never have been achieved.

Interestedness has become one of the most important elements of the management system. Under the present more stringent domestic and international economic conditions the maintenance, increase and expansion of this have become still more important.

The exploitation of the large volume of investments and implements made available for the development of agricultural production is only possible with a simultaneous assertion of interest.

An increase in interest requires a clear, well oriented set of economic regulations, the restriction of privileges and interference from outside, the stabilization of the role of farm management and the possibility to make independent and responsible decisions.

The development of agriculture is the best example of the fact that increased personal interest, the general introduction of cash payments, the extension of task-wages, and the application of various task-proportionate wage forms result in a considerable rise in production and in most cases in an improvement in quality as well.

The rapid technical development and social recognition of agriculture are indicated by the increase in personal incomes. The relatively slight difference in income (approx. 10%) between agricultural and industrial workers in Hungary is almost unparallelled elsewhere in the world. Nevertheless, this is completely realistic, since, with respect to the standard of equipment and labour productivity the large-scale farms have mostly attained — and in certain sectors even exceeded — the corresponding parameters of industrial sectors.

The last ten years have witnessed a structural transformation of production resources. The earlier system of production based on manual labour and mostly on draught power has been replaced by up-to-date technology and industrial materials.

Most of the labour force thus released has found employment in other sectors of the national economy. In the second half of the seventies important processing and subsidiary industrial and servicing activities were set up on the large-scale farms. This gave the opportunity for an on-farm regrouping of the labour force released due to the modernization of agricultural production.

Through the organization of processing activities (fodder mixing, meat processing, wine bottling, etc.) and the extension of industrial and servicing activities within the vertical farm system the economic efficiency of production has been increased, and besides supplying the local population, the intensive production of commodities for domestic and export markets is also carried out. This activity also increases the sources of income and farms receipts.

The demand for further development in production is more and more concerned with the quality rather than the quantity. Quality is importance in the production of fresh goods and basic materials, especially in vegetable and fruit production, and it is here that the incentive to produce goods of high quality plays an outstanding role. The standard of processing must be raised, the packaging improved and the choice further widened both for home-trade and export goods. As regards get-up and packing, the accent should be on differentiation according to market demands and attainable prices. Market orientation must thus be kept in view even when the technical bases for farm development are laid down. This would facilitate the more efficient use of lower investments.

When shaping a long-range production policy it is essential to strengthen the marketing attitude. Development objectives must be set separately for each product or individual sector. taking market tendencies into consideration, and the economic conditions for production must be provided accordingly.

In order to increase the efficiency of foreign trade exports, in addition to a significant improvement in exporting conditions, greater opportunities must be ensured for a co-operation between Hungarian and foreign enterprises, as well as for the purchase of licences. Efforts should be made to counterbalance foreign investments with finished products or to organize joint sales, since it is only possible to secure a market for the long term through up-to-date processing and by joining foreign marketing or processing organizations on the basis of mutual interest.

The successes and failures of the food economy in Hungary both go to prove that development must be based on the coordination of rational objectives, facilities, regulators and interest.

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CHRONICA

BÉLA POZSÁR
(1922—1981)

Hungarian plant physiology and agricultural research has suffered a serious loss: Béla István Pozsár, Ph.D. (biol.), radiobiologist, member of the board of the Botanical Section of the Hungarian Academy of Sciences, died of a severe illness on 22nd July 1981, at the age of 59.

He was born on 15th August 1922 in Budapest. His father was an agricultural labourer, and later a revenue office messenger with a modest income; his parents made great sacrifices to have their three children educated. Béla Pozsár took his school certificate at the A. Fáy secondary school in Budapest, then acquired a teacher's diploma in chemistry and biology at the Teachers Training College, Szeged, in 1945. From October of the same year he was employed as a teacher in Budapest. He married in 1947 and lived in harmony with his wife and son Béla until his death. In the meantime he continued his studies of natural sciences at the Pázmány Péter University, and in 1950, after completing the necessary four semesters, he took his doctor's degree in plant physiology, with biochemistry and zoology as subsidiary subjects. The title of his doctoral dissertation was: "Importance of the action of ethylene in plant physiology".

From 1949 to 1954 Béla Pozsár worked in the Plant Physiology Institute and Botanical Garden of the Pázmány Péter (later: Eötvös Loránd) University as assistant to the late professor Nándor Gimesi. He was primarily engaged in evolutionary biology and biochemistry, but also studied the ion uptake of cells and the transporting processes of the phloem. He was proud of having been a pupil of Nándor Gimesi and always remembered the late professor with warm affection. After Gimesi's death he prepared a number of important posthumous

papers, mainly on cytology, colloid chemistry and biochemistry for the press, and published a list of the master's scientific works in *Acta Biologica* (1957, **VII**/2—3: 131—133).

From 1954 to 1958 he worked for the Publishing House of the Hungarian Academy of Sciences as biological editor, heading a team of the encyclopedia editorial board. In the meantime, in 1956, he attended an isotope course at the Institute of Agrochemistry and Soil Science of the Hungarian Academy of Sciences, and in the institute's isotope laboratory, as well as in the isotope laboratory of the Institute of Genetics, he started the radiobiological research that he then continued for 25 years, up to the end of his life. In these laboratories he first studied questions of lipoid metabolism related with photosensitivity, in order to obtain a better knowledge of the biochemical nature of resistance mechanisms.

In 1958 he also worked for six months at the National Agricultural Quality Testing Institute as a researcher, mainly carrying out chemical analyses on fodder plants. From then until 1963 he was a researcher at the South-East Transdanubian Agricultural Experimental Station at Iregszemcse, where he later became the head of the isotope laboratory. In the meantime he passed the necessary examinations at Gödöllő University of Agricultural Sciences to become a certified agricultural engineer, and in 1962 obtained a doctor's degree in agricultural sciences (with phytopathology as his main subject) after defending a thesis entitled "Toxicology of rust diseases". In this dissertation he emphasized the bioenergetic importance of lysolecithin and of decanoate, a toxic compound which switches off oxidative phosphorylation.

At Iregszemcse Béla Pozsár examined the intermetabolic role of beta radiation isotopes, and studied the biochemical and physiological effects of gamma radiation and neutron flux. The achievements he made there in discovering the correlations between protein and nucleic acid synthesis and phytohormones were of importance even on an international scale.

In 1964 Pozsár defended a thesis with a radiobiological subject, "Effect of gamma radiation on the metabolism of plants", and received the degree of candidate of the biological sciences (equivalent to Ph.D.). In the course of his investigations he demonstrated that the higher green plants were relatively irresponsive to radiation in comparison to animal tissues and to heterotrophic plant tissues lacking chloroplasts, due to the comparative insensitivity of photophosphorylation. In response to ionizing irradiation the activity of dehydrogenases increases, partly explaining the phenomenon of radiostimulation.

In 1963 Pozsár became a senior researcher at the Research Institute for Plant Protection, where he worked for 7 years, until 1970. Having become increasingly interested for some time in physiopathological problems, this institute gave him the opportunity to successfully study the nucleic acid and protein metabolisms of virus-infected leaves and the reduction in the oxidative phosphorylation of rust-infected leaves. He paid particular attention to the special effects of synthetic cytokinins and endogenous cytokinin-like biological activities, such as the stimulation of photosynthetic carbon dioxide ($^{14}CO_2$) fixation (1967: Die Wirkung der synthetischen Cytokinins auf die Steigerung der photochemischen Aktivität des Chlorophylls in Bohnenblättern. *Bot. Közl.*, **54**, 219—225), and the increase in the protein level of the leaf (1971: The determination of the effect of soluble protein level on the intensity of photosynthetic carbon dioxide fixation. *Acta Agron. Hung.*, **20**, 197—203). Later Pozsár and his collaborators (Király, El Hammady) were able to demonstrate a parallelism between protein and nucleic acid synthesis in leaves (1967: Cytokinin effect of benzyladenin: Increase of nucleic acid and protein synthesis in bean leaves. *Nature*, **214**, 273—274). He supplied direct evidence that synthetic cytokinins and endogenous cytokinin-like biological activities raised the absolute and relative level of low molecular weight protein fractions soluble in a 0.5% solution of sodium chloride, thus indirectly increasing the pathological resistance of the leaves. The cytokinins induce rejuvenescence in the plant tissues through the stimulation of protein synthesis, and the increased level of immune-biologically active protein fractions causes resistance to fungal diseases and virus infections (1974: Physiology of host-pathogen interrelation with respect to protein levels. *Acta Agron. Hung.*, **23**, 119—122).

With his collaborators (Király, Matolcsy, El Hammady) he proved that, besides the purine type of cytokinins, benzimidazole and 6-methyl-uracyl also have cytokinin-like effects (1967: Cytokinin activity of benzimidazole. *Acta Bot. Hung.*, **13**, 169—174; 1968: Cytokinin-like biological effectivity of pseudothymine (6-methyl-uracyl): Action of leaf-growth, chlorophyll preservation and intensity of protein synthesis. *Life Sci.*, **7**, 699—704).

From 1970 to 1974 he was head of the Physiological and Biochemical Section of the National Institute of Agrobotany, then in 1974 and 1975, as a chief official at the Information Centre of the Ministry of Agriculture and Food, he edited the Agrártudományi Szemle (Agricultural Review). These appointments enabled him to continue his work at the Research Institute of Plant Protection. With the collaboration of László Horváth he succeeded in demonstrating that benzimidazole and its derivative directly stimulated the intensity of

photosynthetic carbon dioxide ($^{14}CO_2$) fixation in relatively short exposures, not sufficient to induce stimulation at the protein fraction level (1974: Effect of benzimidazole and its derivatives on the intensity of photosynthetic carbon dioxide fixation in alfalfa and maize leaves. *Acta Agron. Hung.*, **23**, 355—358).

The invention "Method of enriching the protein content of green fodder by carbamide treatment during harvesting, and the preparation used in the procedure", registered at the National Patent Office, was the result of Pozsár's work at the National Institute of Agrobotany. The preparation Plantprotam (containing N-propyl-benzimidazole salt as the main active agent) successfully raised the leaf protein level. The preparation and the procedure have been patented in England, Austria, Denmark, France, West Germany, Italy and Switzerland.

In 1975 Pozsár was appointed senior researcher at the Isotope Institute of the Hungarian Academy of Sciences. He worked in the agricultural group of the Organic Chemistry Department until his early retirement in 1979. From then on, right up to his death, he spent more time than ever on wide-ranging research. In this institute he found the creative atmosphere he had longed for so much all his life.

With the co-operation of his collaborators (Matus, Opauszky, L. Horváth) he had previously developed a measuring technique using compounds labelled with stable nitrogen (^{15}N) atoms, suitable for studying the nitrogen metabolism of plant tissues (1970: Comparative mass spectrometric evaluation of incorporation of stable nitrogen into the leaf proteins of Bezostaya 1 wheat variety from labelled ammonium nitrate and urea. *Agrochimica* **14**, 43—440).With this technique he and his collaborators (Iglewski, Szarvas) again succeeded in demonstrating the action of synthetic cytokinins, particularly in raising leaf protein levels (1977: Stimulation effect of synthetic cytokinins on the uptake and incorporation of nitrogen-15-labelled ammonium nitrate and urea in wheat leaves. IAEA, Vienna, 377—382).

Pozsár carried out detailed studies on the levels of cytokinin-like compounds and on their role in the protein-nitrogen metabolism of leaves (1979: Negative correlation between NPN rations and endogenous cytokinin levels in mycelia and leaves. *Acta Agron. Hung.*, **28**, 441—443) and in photosynthetic carbon dioxide fixation (1980: Peak levels of endogenous cytokinins after decapitation in leaves of leguminous plants: Increase of protein and chlorophyll contents and photosynthetic $^{14}CO_2$ fixation. *Acta Agron. Hung.*, **29**, 47—50).

Pozsár wrote an important monograph on the action mechanisms of 6-methyl-uracyl- and its pesticide-type derivatives, discussing the relationship between chemical structure and biological activity [1979:Biological activity of 6-methyl-uracil (6-MU) in comparison with pesticide-type derivatives. *Acta Agron. Hung.*, **28**, 170—184].

It was also an important achievement when, together with Tibor Szarvas, Pozsár demonstrated the presence of free endogenous formaldehyde levels in leaves through the absorption of dimedone (1979: Formation of formaldehyde via photosynthesis in maize leaves. Detection of endogenous formaldehyde. Proc. 19th Hung. Ann. Meet. Biochem. Budapest). Dimedone gives in vitro reactions with aldehydes C_1, C_2 and C_3; after separation and radiochemical identification their photosynthetic origin can be verified. Formaldehyde of photosynthetic origin was also demonstrated by the photolytic decomposition of tritiated water (HTO), and its quantity was compared with the glycose levels.

The many-sided, theoretically well-founded work done on synthetic cytokinins, and the results of preparative organic chemistry made it possible for the Isotope Institute of the Hungarian Academy of Sciences, in co-operation with the North-Hungarian Chemical Works, to apply for a patent in 1980 under the title "A cytokinin-like, membrane-active preparation increasing the productivity, protein nitrogen and anion uptake of plants and replacing kinetin". Pozsár did not live to see the results of this work, though the practical application of various preparations (mainly with benzimidazole, pyridine and phthalazine derivatives as active agent), particularly in vineyards and fodder crop production, proved successful even during his lifetime. Their safe application is confirmed by the data of acute and chronic toxicity. Thus, the results of the plant regulator studies he directed are manifested today in crop production yields.

Béla Pozsár carried out considerable literary activity. His scientific publications (papers, lectures, sections of books) total almost three hundred. He was also the co-author of a number of monographs. For the series "Magyarország Kultúrflórája" (Cultivated Plants of Hungary) he regularly wrote the phytochemical and biochemical sections. He was particularly interested in fungi. One of his favourite ideas was to utilize the organic refuse of cities in mushroom growing. He studied the question of domesticating the mycorrhizal fungi, and as a prominent expert on fungi was enthusiastic in propagating knowledge about mushrooms. As a member of the governing bodies of the Botanical and Mycological Sections of the Hungarian Academy of Sciences he was active for many years in directing biochemical investiga-

tions on plants and fungi, particularly as regards cytokinin research. He was also a founder member of the Pécs section of the Hungarian Biological Society.

His excellent human relationships widened the range of his activity. He maintained close connections with his foreign colleagues, too. He took part in numerous important scientific conferences both in Hungary and abroad, and made study tours for shorter or longer periods to Austria, the German Democratic Republic, the German Federal Republic, France, England, Finland, Holland, Egypt and the United States of America. His works are often cited even by the best-known foreign researchers.

Béla Pozsár was an extraordinary person. His enormous capacity for work enabled him to make a unique contribution to Hungarian plant physiology. He had a very clear vision of scientific problems and always perceived the practical implications of seemingly abstract theoretical questions. His modesty was coupled with a sensitive conscience. Nobody could surpass him in attentiveness and helpfulness.

His rich, though short life is a gold-mine for all of us, and his intellectual inheritance will be multiplied by the workmen of science. The memory of his charming personality will live on, and his life-work will be of great profit to those who come after.

L. Gy. Szabó

JÓZSEF UJHELYI

1910—1979

József Ujhelyi was born in the village of Ecser (Pest County) on 4th May 1910. His father was a lawyer by profession, but was also fond of nature. While a secondary school student at Selmecbánya, he was taught natural history by Adolf Cserey, who implanted in him a love of nature. Due to his father's influence Ujhelyi soon became acquainted with the animals and plants in the hills around Ecser and in the meadows and groves along the River Danube. He began his elementary education at Ecser but finished it in Budapest, after his family moved there. He received his secondary education at the István Grammar School (1920—1928). The good atmosphere prevailing there and his participation in the boy-scout movement favourably complemented his careful family upbringing. It was during this period that the bonds which linked him with nature became still tighter. He became more and more

interested in plants. His brother Sándor, who was eight years his senior and himself drawn towards plants, helped to strengthen his affection for nature.

His father died relatively young, at the age of 52, in 1926. All the burdens of the family were then imposed on his mother. József Ujhelyi would have liked to follow his brother's example and attend the university, but partly because of the financial situation of the family, and partly on medical advice he decided to choose a career in horticulture. After leaving secondary school he served for a year as a probationer in the gardens of the Royal Castle in Buda, and then enrolled at the Horticultural College, where he attracted the attention of his teacher, Béla Husz. On his teacher's advice he followed his old desire, and after the first year enrolled at the faculty of arts of the Pázmány Péter University, to train as a teacher of natural history, geography and chemistry.

Béla Husz called the attention of János Tuzson then professor at the Phytotaxonomy Institute of the University, to his protegé. Tuzson kept track of his progress and was satisfied to see that his pupil excelled not only in botany but in the other subjects too. József Ujhelyi was a scholarship-holder, exempt from the payment of tuition fees, throughout his university career (1930—1934). Tuzson's vast knowledge, and unique teaching ability, and the simple, objective construction of his lectures made a deep impression on the young man thirsting for knowledge.

Tuzson expressed his satisfaction by inviting the then fourth-year student to act as a paid assistant, a choice he never had to regret. József Ujhelyi felt that his dreams had come true. Up to the end of his life he spoke with nothing but love and respect about Tuzson's reserved personality and his exemplary conduct towards his young associates.

During his years of teaching at the university Ujhelyi developed a gift for teaching. His assistance and later supervision of laboratory work and his lectures soon made his name known. The students both liked and respected him; they respected him as a lecturer who was perfectly reliable in professional matters, and whose every word gave evidence of a devotion to botany, and liked him as a gay, good-humoured, but always moderate man. He was given nicknames and funny songs were sung about him, at which he laughed the most.

József Ujhelyi was one of the founders of an informal group set up to provide lecturing and publication opportunities for ambitious young botanists. The first fascicule of the new periodical "*Borbasia*" was published at the beginning of 1938. Ujhelyi was the editor of volumes 2 to 4 (1940—1944). On the front-pages of the fascicules of Vol. 3 the pulsatilla emblem with the inscription "Hungarian Botanical Society 1940" appeared, indicating that the informal group had been organized into an officially recognized scientific association. Only 9 volumes of the journal were ever edited, since publication was discontinued simultaneously with the dissolution of the Hungarian Botanical Society in 1949. The story of this society has yet to be included in the history of Hungarian botany.

In 1937 József Ujhelyi obtained a doctor's degree in phytotaxonomy, geography and mineralogy. In 1938 he became a titular professor's assistant, in 1940 a salaried professor's assistant, then from 1942 an assistant lecturer. The salary he received from the university was not sufficient to live on, even for a modest young man like him, so he also undertook other teaching assignments. He delivered lectures in botany at the Budapest Teachers' Training College from 1938 to 1944. He also taught botany under the supervision of Béla Husz at the Academy of Horticulture (formerly the Horticultural High School, later the College of Horticulture) from 1939 to 1944. Between 1941 and 1944, in addition to conducting practical courses and proseminars at the university, he delivered lectures in plant taxonomy at the request of the professor of botany, Zoltán Szabó, who was seriously ill. Due to the outbreak of war, he did not become a private docent in the taxonomy of monocotyledons until 1945. Between 1945 and 1950, though no longer employed at the university, he was still invited to deliver lectures or conduct examinations on various occasions.

In 1943 he married Ilona Irányi, a former pupil of his, with whom he lived in harmony for the rest of his life.

In August 1945 Ujhelyi was invited to take the post of director at the Botanical Department of the National Museum of Natural Sciences. He worked there from November 1945 until 1950. At that time the Botanical Department was situated on the 2nd and 3rd floors of the Hungarian Academy of Sciences, which was still in the damaged state caused by the war. Ujhelyi's first step was to organize a work party made up of employees from the Botanical Department and university students who volunteered for the job. They cleared away the debris and useless wreckage, and later, after the building had been renovated, put the collection and the library in order. In this way life returned to normal in the Botanical Department far earlier than in many other institutions.

Ujhelyi's other great objective was to have the invaluable collection transferred to a safer place. The plant collection was previously stored in fine pine-wood cases which were not

airtight and which could easily be set on fire. Ujhelyi ordered designs for tight fitting cases made of aluminium plates. He succeeded in gaining the support of the Planning Bureau and was thus soon able to order the first 70 herbarium cases. The more than half a million forints paid for these cases, then a novelty even abroad, showed not only the understanding attitude of the government but also the acknowledgement of Ujhelyi's work. His name was already known, and his consistently objective opinion was requested even on personal matters. Owing to his unselfish, competent and tireless activity, there were those who would have liked to see him at the head of the Botanical Institute of Debrecen University. He refused the complimentary offer, as in his view the Institute already had a professor. The professor, R. Soó, on the other hand, who later became a prominent representative of Hungarian botany, never forgave Ujhelyi for once being considered suitable to replace him in the university chair.

He was able to promote the cause of the Botanical Department in one more field, by increasing the number of staff from 9 to 22. Though in no way at the expense of other departments of the Museum of Natural Sciences, this happened with the circumvention of the management. So despite Ujhelyi's protest that a rapid, immediate decision had to be made, the management was offended. This had bitter consequences for him later.

When the National Centre for Museums and Monuments was established in 1950 he was appointed head of the Natural Sciences Group. He regarded this as a further sign of recognition and also as a fine opportunity to continue doing something for the Botanical Department. Thus, he parted — though with a heavy heart — from the Botanical Department, where he had succeeded in creating conditions under which he could have occupied himself solely with botany. Bálint Zólyomi became the new director, while Ujhelyi took the post originally intended for Zólyomi, and kept in until 1952. He participated in the development of museology on a national scale, delivered lectures, organized exhibitions, and took part in the elaboration of the curriculum for a museologist's training course. Most of his time was spent in administrative work and very little was left for dealing with botany. When the new system of scientific qualification was introduced he was neglected, and was not granted even a C.Sc. degree (equivalent to Ph.D.), on the grounds that he had published very few scientific papers. Although he knew that this decision was closely connected with the Debrecen episode, this was the final straw which sent him back to the Botanical Department in July 1952, this time as a subordinate.

It requires great tact and understanding from both the head and the subordinate when somebody occupies a subordinate post where he was previously the head. This is particularly true when the present head appears to have aided the development of the current situation. Ujhelyi thought the Botanical Department would be the best place to carry out his plan to revise the Hungarian flora on a broad basis, taking new aspects into consideration. When he was the director he had envisaged this plan in the form of a research programme. However, the fact that he left the Botanical Department at that time, and that the funds and staff available were required for the purposes of plant coenology and flora mapping, prevented him from beginning to carry out his plan. But in 1952, he finally had the necessary conditions at his disposal and could set to work, though unaided.

For a while, however, he was charged with numerous organizational tasks: he was elected as organizing secretary of the Hungarian Biological Association, then as assistant secretary-general of the Hungarian Biological Society until his resignation in 1955. In the meantime he had recommenced his work on the revision of the species of the genus *Sesleria*. He wrote his doctoral dissertation on this subject as early as 1937. Right at the start he successfully applied the epidermis test, which formed an useful complement to the meticulous morphological observations. A few years later he used cytotaxonomic data for the differentiation of species. *Sesleria sadleriana* Janka proved to be an octoploid species, while *S. varia* (Jacq.) Wettst., which was very similar to it, proved to be hexaploid. This statement is very important, because it is here that we find one of the pillars of Ujhelyi's systematic work, the recognition of the importance of polyploidy. From this period onwards he complemented detailed morphological examinations, epidermis tests and observations on living plants with cytotaxonomic data.

He was convinced that the examination and observation of living plants were indispensable for the correct evaluation of the herbarium material. To introduce living plants into the nursery was relatively easy when they were wild plants native of Hungary, but to get living material of foreign species was rather more complicated. In many cases botanist colleagues visiting the places in question brought living material, but more often the plants had to be raised from seed. In fortunate cases the caryopsis of a herbarium specimen was found to be still capable of germination. In general the living material was supplied by plants raised from seed obtained from foreign botanical gradens through a seed exchange, naturally after a scrupulous identification of the plant raised. Series of sections were made from the

root tips of living plants for chromosome examinations, while epidermis peelings were taken from the leaves, as in the case of herbarium specimens. The micrographs of the latter were magnified to the same size — 9×12 cm — for the sake of easier comparison.

He intended to publish his results only in the form of a *Sesleria* monograph. His modesty prevented him from advertizing his work. Nor did he want his name to be mentioned by succeeding generations as one of those who advertized themselves by talking about their plans as if they had already been executed. Thus, outsiders did not see much promise in his work. Obtaining the living material required the establishment and maintenance of contacts, and also a great deal of administration, which he had to carry out himself. This was extremely time-consuming and appeared to those who knew little about it as a meticulous but incoherent mass of work which never came to anything. At best Ujhelyi was referred to with a patronizing smile as "old Joe who likes gardening" rather than being qualified as a mere dabbler.

His work certainly required no small amount of gardening, under conditions which were far from easy. He planted the seeds in pots kept on his table or on the fortunately large window-sill in his study. The emerging seedlings were raised on the window-sill or between the two window-panes until they became strong enough to be planted out. There were often 40—50 pots in his window. He had a garden measuring a couple of square metres by the wall of the Vajdahunyad Castle in Budapest City Park, that he himself had dug up, cleared of debris and made suitable for his plants. Root tips can be obtained from a plant at a much earlier stage, but three years are generally required before it reaches the flowering stage and until that time it needs a vast amount of hoeing, weeding and watering. Ujhelyi never lived to posses even a tiny greenhouse to propagate his favourite Seslerias, then Koelerias and Achilleas in.

Ujhelyi was convinced of the importance of tracing the development of his plants, as he felt this was the only way to acquire a knowledge of their genotypic characteristics, and not just their phenotypes. When urged by his friends to publish his paper on the Italian *Sesleria* species (1959) he mentioned Deyl's *Sesleria* monograph in the introduction. He emphasized that objections could be raised against the monograph since it was based purely on the phenotypic classification of a herbarium. Among the 9 *Sesleria* species of Italian origin described in Ujhelyi's paper three are new. Another paper on *Sesleria* was published in the same year in Fedde's Repertorium under the title "*Species Sesleriae generis novae*", with the description of 6 new species. The two papers were the result of many years of untiring work. Among the new species *Sesleria hungarica* Ujh. caused particular excitement, as it has so far escaped the attention of botanists searching the Bükk Hills. This shows, among other things, that to declare that research into the Hungarian flora had been completed simply in order to promote coenological investigations was, to put it mildly, somewhat premature.

Ujhelyi was convinced that polyploidy could be found in other genera as well, and that the discovery of this would make the true system of nature obvious. This was proved for the genus Lotus in his paper on the taxonomy of the *Lotus corniculatus* L. *(sensu lato)* species group, published in 1960. Seven species, three of them new ones, are discussed in it. Of the new species, *Lotus borbasii* Ujh. was the most striking. This species can be found from the Buda Hills through South-West Slovakia to the southern part of Moravia and the eastern half of Austria, and also in the Illyrian region. However unbelievable it may seem, this meant that a new species, and by no means an insignificant one, had been discovered in the heart of the country, in the very centre of scientific activity. The great discovery was not welcomed by all. Some felt it as a threat to their scientific prestige and tried to diminish the importance of the new species. It was only under the influence of the indirectly expressed opinion of impartial Canadian researchers that the "storm in a tea-cup" calmed down.

The two papers on *Sesleria* and the one on *Lotus* made Ujhelyi's name known to foreign representatives of the profession. When visiting Hungary some of them called on him to acquire a better knowledge of his work. Ujhelyi spoke of his work willingly and enthusiastically. He knew that he had no need to be ashamed of his achievements, and that the interest shown was a sign of acknowledgement. *Lotus slovacus* Zertova, the synonym for *Lotus borbasii* Ujh., owes its existence to the unprofessional use of information received from Ujhelyi on the occasion of such a visit.

Due to the favourable international reception of his work he postponed carrying out his original plan, to write a monograph on the genus *Sesleria*. His creative spirit urged him to fulfil a greater task, since he had clarified the position of almost all the dubious taxa of the genus *Sesleria*. The other task he had long intended to accomplish was to study the species of the genus *Koeleria*.

Koeleria species can be found all over Europe under the most diversified ecological conditions. Although they occur in other places, too, most of the taxa described are natives of Europe. Their diversity, and the large number of taxa described have always caused serious

problems to taxonomists. Since the appearance of Domin's monograph (1907), his classification has generally been accepted, at the most with minor alterations. The monograph, which brings out the full hierarchy of taxonomic units, does indeed make a deep impression. Its main deficiency is that it is based exclusively on the classification of herbarium stocks. Consequently, it cannot satisfy phylogenetic principles based on genealogical relationships, as Ujhelyi pointed out in his first paper on *Koeleria*, published in 1961. He was by no means satisfied with the system of Domin's monograph. In his very first paper he established the existence of polyploid series. The species included in the series often came from different sections according to Domin. It was thus obvious that the difference between Domin's system and classification on a phylogenetic basis was irreconcilable. Ujhelyi made continuous references to Domin's monograph, partly because the latter was the fullest inventory of *Koeleria* taxa, and partly because by refuting Domin's system he was passing judgement on other treatments of *Koeleria* too.

In the course of the years (1961—1974) Ujhelyi published a total of 12 papers on *Koeleria* species. He set up a total of 18 series including 55 species, 29 of them new ones. For many plants earlier described as species but later degraded to taxa of lower rank he demonstrated that the original classification had been correct. The majority of Koelerias is listed as extraneous: the areas on which an overwhelming proportion of the taxa discussed grow do not include Hungary at all. From the point of view of obtaining the necessary plant material this caused difficulties; nevertheless, Ujhelyi did not stop at the borders of the country. He was convinced that the unanswered questions raised by the Hungarian flora could not be settled without the European flora. He always regretted not having the opportunity to study the *Koeleria* species of the western countries in their natural surroundings, and would very gladly have included species native to North Africa, Asia Minor and the southern part of the Soviet Union among those to be studied. However, he knew only too well that those were dreams that would never come true.

From the point of view of his work it was a great advantage that Árpád Dégen's herbarium was in the possession of the Botanical Department. Domin had processed the Dégen herbarium, so it contained many Domin types, and plants revised by him. Yet, this herbarium, however rich, was not sufficient in itself. Ujhelyi had to borrow material from quite a range of foreign herbaria in order to study the different types. He could not, however, set about studying the living material unless he used the method employed earlier with the genus *Sesleria*.

Ujhelyi repeatedly declared that he wanted to see the principle that taxonomy had to reflect the actual descent prevail. It is important to know the ecological conditions of the growing site, otherwise the morphological features cannot be correctly interpreted. Observation in the nursery can never be more than a partial substitute for this. It can be said without exaggeration that even if his concepts were correct in every respect his work would not have yielded such excellent results if he had not been in so very close a connection with nature. His childhood, the years at secondary school and university, and the time he spent in teaching represented a constant relationship with nature, though of varying intensity. Later he continued to walk about with his eyes open, and noticed many things that escaped other people's attention. He walked all over the country with the purpose of getting acquainted with the Hungarian flora, and collected plants in Transylvania and the North-Eastern Carpathians. In 1938 he roamed about Bulgaria for 6 weeks, particularly in the Pirin Hills, with Antal Pénzes as his companion. In 1943 he visited the Austrian and Bavarian Alps for a 6-week study tour. He collected plants in Albania in 1955 with Sándor Jávorka and in 1956 with Ödön Szatala, for 5 weeks on each occasion. In 1959 he spent four weeks collecting plants, chiefly Koelerias, in Bulgaria. In 1969 he went to Transylvania, where again he collected mainly Koelerias.

His taxonomic studies, in particular those related with *Koeleria* species, confirmed his conviction that the existence of polyploid series could be assumed in all genera where the diversity of the species caused difficulty to the taxonomists. Cases where the diversity is demonstrably caused by a high degree of hybridization are, naturally, exceptions. In Ujhelyi's opinion diversity due to hybrids is characteristic primarily of areas disturbed by human activity, while the polyploid series are more frequent on more or less undisturbed areas still in a natural state. In this respect there is no difference between monocotyledons and dicotyledons, as proved by the studies he made not only on *Sesleria* and *Koeleria* species, but also on the genus Lotus. The genus *Achillea* would appear to be another material suitable for examination.

Studies on the abundant herbarium material had already suggested that there was a lot to be done in this field. More intensive investigations into the *Achilleas* began in connection with some extremely interesting material collected in 1965. The species was described in a paper published in 1975 as a new species named *Achillea horánszkyi* Ujh. The same paper

presented two further new species and, more importantly, established a new section (*Crithmifolia* Ujh.) of the genus *Achillea*. The species in this section have, among other things, an extraordinary feature, namely, that the root system is a so-called "radix cormiger", i.e. shoots develop directly from the root system. This phenomenon occurs in other genera too, but in the genus *Achillea* it is confined to this new section. The species in the section were found in various sections in the former system. This, too, was indicative of the difference between the old and the new principles of classification. The study lists the species belonging to the new section on the basis of examinations of living material and herbarium specimens. Here, in addition to many other important remarks, attention is called to the taxonomic significance of the fruit. The morphology of the fruit in the genus *Achillea* was previously neglected by the taxonomists, as they attached primary importance to the habit of the plant in blossom. In the characterization of the new section the fruit also has a major role.

Ujhelyi's studies on the herbarium specimens of the genus *Achillea* opened up wide vistas. He could see that a detailed treatment of the species in the new section would throw light upon many new questions which had never been discussed so far. But this had to be accompanied or preceded by a revision of the *Achillea* material in the Hungarian herbaria, since in his experience the identification of the *Achillea* material was extremely unreliable. For example, on the basis of the herbarium material he had studied he had the impression that *Achillea millefolium* L. (s. str.) occurred only on the western borders of Hungary and in the Zemplén Hills, although numerous specimens from other regions of the country had been given this name. He did not take a stand on this matter, however, until he had carried out a thorough revision of the herbarium specimens.

Ujhelyi worked with undiminished energy, though from time to time the deaths of colleagues, friends or acquaintances much younger than himself warned him that time was running out. His mother died in 1957 at the age of 72. In 1975 four of her 6 children were still alive: Sándor (retired assistant professor), József (assistant head of department in the Botanical Department), Károly (head of the Serum Production Section of the National Institute of Public Sanitation) and Izabella, Mrs. László Fejes-Tóth (teacher of physics and chemistry). József Ujhelyi's only child, Ilona (born in 1944) was a microbiologist, qualified to teach biology and chemistry. Ujhelyi mentioned his two grandchildren often and with the real pride of a grandfather. In 1977, after 44 years in the service of Hungarian botany, he retired, but he had no intention of spending his time idly when a pensioner.

By that time he had nearly completed his work on the genus *Koeleria*, though he still needed some living material for the examination of a few critical taxa. He felt that the writing of the *Sesleria* monograph should have priority. The revision of the herbarium material of the genus *Achillea* seemed to be a relatively easy task, although the gaps in the living material caused difficulties. He planned to obtain this and the rest of the living material for *Koeleria* while completing the *Sesleria* monograph. He studied seed exchange lists and wrote letters requesting living plants and seeds.

Prior to setting to work he wanted to have his flat renovated. From the outside gallery leading to his flat he had a fine view of Hármashatár Hill, one of his favourite sites for collecting botanical specimens. He soon discovered what a difficult task he had undertaken. Due to the lack of skilled craftsmen he painted the walls and doors himself. Then he began to systemize the material of his early collection tours. A further task was to arrange and return the *Sesleria* and *Koeleria* material borrowed from foreign herbaria. To each sheet he attached a 9×12 cm magnified micrograph of the epidermis peeled off the leaf of the specimen, and a revision card, and he enclosed some herbarium material from his own collection with the parcel.

He was disturbed by the fact that now and then he felt dizzy while working, and sometimes had an attack of giddiness in the street. Then certain common words slipped from his mind in mid-sentence. After being examined by his local doctor, he was admitted to hospital. He willingly submitted himself to a series of tiring tests, which turned out later to have been performed to instruct the medical students rather than to restore his health. The medical tests did not show any particular problem and he was discharged from hospital. On medical advice he took long walks in the open air and his condition seemed to show a slight improvement. Then he was taken to hospital again, and soon afterwards his friends were startled by the news of his death. His ashes rest in an urn in the Óbuda cemetery. The herbarium material he collected can be found in the Botanical Department of the Museum of Natural Sciences (Budapest, Könyves Kálmán körút 40.). His extremely valuable living plant material is in the care of the Soroksár Botanical Garden of the University of Horticulture and the Vácrátót Botanical Garden of the Hungarian Academy of Sciences.

Ujhelyi was of smaller than average build. His fair hair turned white and thinned in the course of the years, but his personality retained its youthful freshness and liveliness. He remained straightforward, sincere and serene, and was fond of company to the last.

Just as plants are ignorant of political frontiers, for Ujhelyi it was the territory bounded by the Carpathians rather than the red, white and green flag or the Hungarian coat of arms that he associated with the homeland. He was interested in everything related with the country's past, and regarded the Hungarian people, particularly the Hungarian peasants, as the central figures in the history of Hungary. Memories of his childhood, the "Dezső Szabó" circle to which he belonged even in his university days, the books he read, including the startling reports of rural sociologists, the figure of Péter Veres, the peasants in the novels of Gyula Juhász and Zsigmond Móricz, the spirit of the thirties which aimed at teaching self-knowledge and discovering what it meant to be a Hungarian — this was all reflected in the picture he formed for himself of the Hungarian peasant. If he had been a sculptor he would have made a statue in stone or bronze of the Hungarian peasant's imperturbability, wise indulgence, straight carriage, and the playful force of his dance.

Nothing was farther from Ujhelyi than a narrow-minded chauvinism; this was inconsistent with his friendly, humane nature. During his foreign tours he became acquainted with the Bulgarian peasant, the Albanian shepherd and the Transylvanian Romanian, who all gave him a friendly reception and shared what they had with him. In his opinion the friendship betwen nations is just a slogan, much more important is the friendship between individuals. He himself easily made friends; his informal manners and sincere interest quickly won people, particularly children and women. He was closely attached to his friends, felt concern for their troubles and often helped them even in opposition to his own interests. He was a man for whom friendship was a sacred bond, who could always be relied upon and with whom it was worth sharing joys and sorrows.

Ujhelyi always enjoyed the company of young people, understood their problems and readily offered them his help. He felt it was his responsibility to impart not only his professional knowledge but also his experience. His speech, accompanied with sweeping gestures and a vivid expression, was listened to with attention. He often spoke about things he had read: he liked to read ethnographic, geographic and historical works, and took particular interest in books on archeology and in travel books. He looked forward to all the reading he would do once he was retired, including novels. Sometimes the conversation stemmed from some event in the Botanical Department or elsewhere. He often talked about professional matters; his words reflected the same love of botany that he once felt as a young university lecturer. He believed that botany should be studied for its own sake. Those who chose botany as a mere career with prospects of success were intruders in his eyes.

Ujhelyi convincingly argued that personality was a decisive factor in science. His positive examples were taken estimable persons he was closely acquainted with: János Tuzson, Gábor Andreánszky, József Bánhegyi and others. He could also cite a considerable number of negative examples. He felt it was totally impossible for a subjective, self-centred man, who regarded any means as good enough to achieve his personal aims, to do scientific work in an objective way, which meant subordinating his own views to the facts.

It is not the number of publications which is important, despite the fact that this is officially encouraged. Much more important is the concept behind the publication, and the work it is based on. Mass production involves a higher percentage of waste. It is extremely harmful that some researchers make use of their connections to publish the same paper in two or three places. It has happened that a superior published the work of a subordinate under his own name, or that a paper published in a foreign language can also be read in a Hungarian journal, once under the name of the superior, and in the second case as the subordinate's work. Such cases naturally give rise to the desire to put a stop to man's exploitation of man for once and for all.

In Ujhelyi's opinion the botanist who uses the term "transitus" in plant taxonomy resembles the physician who observes a new group of symptoms and gives it a Latin name to designate a hitherto unknown disease: neither of them knows anything about the essence of the phenomenon as yet. Thus, if the term transitus is used, it always indicates the deficiency of our knowledge, and the plants in question must be very carefully examined. In many cases it turns out that they can be quite easily explained by the variability of species, or that the "confusion" is caused by failure to identify a species or by an unwarranted unification of the species at a later date. Nor must it be forgotten that when the ecological conditions change due to human intervention, species with quite different requirements often occur at the same site. One species is still to be found while another, better suited to the changed conditions, has already begun to take its place.

The type of "classification" that simply involves shuffling the herbarium specimens from one place to the other, or modifying the order of the taxa, is a pointless game, in Ujhelyi's opinion, which does not yield any result apart from the fact that, on the basis of the rule of nomenclature, the person producing the "combinatio nova" will be proud to have his name

become known. He also disliked the fact that there were as many taxonomic systems as there were books on taxonomy. Even writers who were not actively involved with taxonomic questions, but had read a few papers on the subject, felt competent to set up a "new" system. This has the advantage for the author that having read further studies and making certain alterations he can publish from time to time new, more up-to-date variations. In each case the result is a "new publication".

He repeatedly emphasized in his papers, too, that he considered the herbarium classification system an out-of-date method, and a harmful one as well, since it brought discredit on the phylogenetically-based method of classification. As a particularly out-of-date freak he mentioned the so-called apogamous small species set up by Soó within the species *Ranunculus auricomus* L., and the lack of comprehension, suggestive of an "outsider", encountered in "A magyar flóra és vegetáció kézikönyve" (Handbook of the Hungarian flora and vegetation) when listing the Hungarian taxa of the genus *Koeleria*, where Domin's and Ujhelyi's taxa are mixed as the water and fire were in the mythological "*aurea aetas*" (golden age).

In the field of systematics the researcher has a single task: to discover the facts of phylogeny. He himself was most pleased when the previously neglected species of earlier authors (e.g. F. Schur) proved to be correct. If he thought it necessary he modified the order of taxa, but always after giving a detailed justification. He was aware that his method of classification yielded so many new and surprising results that it would take time for them to become understood and accepted. At first he was upset when he saw that the taxa he had described were placed in a lower order or referred to as synonyms in the Hungarian literature without any explanation being offered. However, knowing the author's character, he understood that the former thought it unnecessary to find explanations, since the enthusiastic praise or the silence that could be taken as consent could be taken for granted anyway. Thus, when finding *Achillea horánszkyi* classified below a species under a freshly created name, which — while conforming with the rules of nomenclature — was quite unusual in international practice, he was no longer surprised. Knowing the personal reasons for this, he would have been more surprised if the author had proved to be objective.

Ujhelyi considered the species placed in series to be true species. They are linked by origin but distinguished not only by the different chromosome numbers but also by morphological differences, geographic distribution, ecological requirements and the different roles they play in the history of vegetation. These last three factors mean that natural polyploid species must not be equated with artificially produced polyploids.

Ujhelyi was not alone in his reservations concerning the view that mathematical statistics and particularly compouter programmes are the "only methods giving reliable results". The over-intensive propagation of these methods has had undesirable consequences. Many use them only as an attractive packaging, or to get an idea sold. There are some who use them to prove, in lengthy studies, what has never been doubted by anybody. Finally, some authors find it convenient to employ these methods, believing that they will thus be freed of the responsibility of making decisions or even of thinking. The opinion of many was once summed up by Ujhelyi in the following way: "A straw-hat is very pleasant to wear — in summer. I have not much hair left, so I like to wear one myself. Yet, I think — though I may be wrong — that even in summer it can seldom be an exclusive article of clothing." Then with a sudden association of ideas he added: "Do you think that everybody in the Botanical Department will be obliged to wear a straw-hat?"

Ujhelyi was always interested in new ideas. As the result of investigations on the seabottom a theory of global tectonics was set up in the first half of the seventies. This theory has fundamentally changed our views concerning the palaeogeography of the Earth. Ujhelyi was among the first to recognize its evolutionary and phytogeographic implications. He delivered a lecture on the subject jointly with István Milkovics at a meeting of the Botanical Section of the Hungarian Biological Society held on 21st May 1974, far in advance of publications appearing on the subject abroad. Unfortunately, however, the text of the lecture has never been published.

He is no longer among us. He went away in haste, leaving behind his Koelerias, Sesslerias, Lotuses and Achilleas to remind us of him.

With the same self-evident simplicity with which he carried his huge knapsack on his collecting tours, he chose to undertake difficult pioneer work instead of looking for more convenient solutions. The result has proved him right. On a European scale he accomplished an important task by studying the genera *Koeleria*, *Sesleria*, *Lotus* and *Achillea*. The vistas opened up by his ideas and investigations are still not properly valued. His name has its place on one of the most brilliant pages of the history of Hungarian botany, among the names of prominent researchers of the Hungarian flora, somewhere in the vicinity of Vince Borbás's name.

S. Tóth

AGRICULTURE ON HUNGARIAN MEDALS
I. PROMINENT CHARACTERS OF HUNGARIAN AGRICULTURE ON MEDALS

In recent years Hungary has become one of the world's leading countries with respect to agricultural production and the food industry. This internationally acknowledged fact is due not only to the hard-working nature of the agricultural workers, but also to the application of the most up-to-date methods of cultivation.

The development of agriculture in Hungary began barely two hundred years ago on the basis of experience obtained in western countries with developed agricultures. Among the initiators, those who appear on medals will be discussed in this paper. However, the history of Hungarian agriculture records the work of many scientists of the late 19th, and particularly of the 20th century, whose pioneer work has also been recognised abroad. Their achievements and experience have become widely known partly through educational establishments, and partly due to papers published in scientific journals both at home and abroad. Some of them initiated the establishment of experimental stations in various fields, others laid down the foundations of scientific and research institutes which are now well-organized, and which have contributed to a great extent to the outstanding results of the present agriculture and food industry of Hungary. The names, memories and successes of some of the more celebrated are preserved by those commemorative, prize and award medals which bear their names and images.

Since the Renaissance medals have mostly been made for special occasions, to preserve the memory, image and deeds of certain people. They make the excellence of those illustrated by them known to a wider public, since they are mostly issued in fairly large numbers. One specimen usually finds its way into a museum, where it testifies to the eminence of the person represented virtually forever. Most of the medals are two-sided; the obverse side generally shows the portrait and name of the person concerned. If the medal is issued after the death of the person represented, the dates of birth and death are also indicated. On the reverse side all kinds of illustrations and symbols are to be found, but they are always in close connection with the person represented and refer to his/her life-work and merits, as does the inscription on the medal. The medal usually bears the hall-mark of its maker. This "Benjamin" of sculpture is, in fact, a small monument, which differs from other sculptural works in that it can be picked up and inspected closely, whereby an intimate relationship can be established between the work and its observer.

Agriculture is a very popular subject among medal-makers, who often use its forms and symbols to express ideas of a broader meaning. (The sower, or the tree planter, for example, express ideas in a figurative sense, too.) In spite of changes and modernization in farm implements the old symbols (sickle, wheat-sheaf, etc.) are suggestive even today. The representation of people doing agricultural work receives considerable emphasis on Hungarian medals, together with old and new farm implements, as well as the animals which play an outstanding role in agriculture, particularly the horse, which is also a symbol of freedom.

However, this paper is primarily intended to review medals made in memory of people who carried out pioneer work in one or another branch of agriculture, namely in soil cultivation and amelioration, plant cultivation and protection, animal breeding and veterinary therapeutics, horticulture and fruit-growing, forestry and water management, agricultural mechanization, agricultural education, or by investigating the history of agriculture and collecting agricultural relics.

Count György Festetics (1755—1819), a big landowner, experienced on his own estate the extent to which agriculture in Hungary lagged behind the agricultures of more developed countries. With a view to carrying out modernization he invited János Nagyváthy, an agriculturist who had obtained experience in western countries, to be the manager of his estate, and in 1979, on Nagyváthy's advice, he established the Georgikon, one of the first agricultural colleges in Europe, on his estate at Keszthely. The college included a 900 cad.yoke (517.5 ha) model farm. The best agricultural experts of his time were invited to be his advisers or to teach at the college. On the medal made (without a hall-mark) in commemoration of Festetics (Fig. 1) the inscription framing his half-length portrait on the observe also witnesses the extent of his interest: Gróf Festetics György 1797. A Georgikon alapítása 100-ik évfordulójának emlékéül (Count György Festetics 1797. In commemoration of the 100th anniversary of the establishment of the Georgikon). And on the reverse of the jubilee medal the inscription surrounding the picture of the new college building: Keszthelyi M. K. gazdasági tanintézet új tanépülete felavatásának emlékéül 1897 (In commemoration of the inauguration of the new college building of the Hungarian Royal College of Agriculture, Keszthely, 1897) indicates the fact that the centenary celebration coincided with the opening of the new college building. The eared struck bronze medal is 30 mm in diameter.

The Keszthely group of the Society of Hungarian Medallists had a set of medals made at the State Mint illustrating the respectabilities of the town of Keszthely. On the observe of one of the medals the half-length prtrait of the founder of the college is seen with the inscription: Festetics György 1755—1819 (György Festetics 1755—1819). The hall-mark KZ below the dates indicates that it was designed by Zoltán Képíró. The reverse shows the first building of the college, the inscription Georgikon above it refers to the connection between the old building and that represented on the medal. The silver patinated medal made of tomback and multiplied by striking is 60 mm in diameter.

János Nagyváthy (1755—1819), the most respected representative of his profession in his day, was the author of the first Hungarian agricultural handbook. The Keszthely estate under his management was organized into a model farm to complete the School erected at his suggestion, and of which he was the principal for a while. The medal made in 1977 by the sculptor Walter Madarassy (holder of the Munkácsy Prize and Artist of Merit) is connected with this aspect of his work (Fig. 2). On the observe, between the inscription Nagyváthy János and the dates 1955—1819, there is a half-length portrait looking to the right and attired in the style of the period, with the hall-mark MW on the left (Fig. 3). On the reverse, a man opening a gate symbolizes the reception of science; above and below it the inscriptions: Georgikon, and Keszthelyi gazdasági szakiskola megszervezője és első vezetője emlékére (In memory of the organizer and first principal of the Keszthely Agricultural School) can be seen. The cast bronze medal is 84 mm in diameter.

On the obverse of the medal ordered by the Keszthely medallists the inscription Nagyváthy János and the dates 1755—1819 are placed on the right and left sides of a portrait taken from a contemporary prototype, with the hall-mark KZ. On the reverse a draught plough of the type used in his time and an open book symbolize Nagyváthy's excellence in theory and practice. The silver patinated medal made of tomback is 60 mm in diameter.

Ferenc Pethe (1763—1832), agriculturist, was the editor and publisher of the first Hungarian agricultural journal "Vizsgálódó Magyar Gazda". He played a pioneer role in the populatization of windmills and the propagation of industrial and fodder crops in Hungary. The present age paid fitting respect to his wide-ranging, progressive work when in 1963, on the 200th anniversary of his birth, a commemorative exhibition was organized in his honour at the Agricultural Museum. On that occasion a medal was made by Ferenc Csucs, a prominent Hungarian medal-maker (Fig. 4). On the obverse the inscription Kisszántói Pethe Ferenc 1763—1832 and the hall-mark Csucs surround his portrait (head and shoulders), which is in contemporary attire; the face is slightly turned to the right. On the reverse, among the group of historical museum buildings the replica of the Vajdahunyad Castle is plastically represented. The inscription Mezőgazdasági / Múzeum / Emlékkiállítás (Agricultural / Museum / Commemorative Exhibition) below it, and the date 1963 to the left refer to the event. The cast bronze medal is 98 mm in diameter.

The Keszthely group of medallists also remembered him, as one of the organizers, instructors, and later the principal of the Georgikon, in their series of medals. On the obverse of the medal the inscription Pethe Ferenc and the dates 1763—1832 are found on the right and left of the portrait, made after a contemporary representation, together with the hall-mark KZ. On the reverse, hands holding an ear of wheat symbolize his fruitful practical work, as he was also the manager of the model farm attached to the college. The silver patinated medal, measuring 60 mm in diameter, was made of tomback by striking.

Sámuel Tessedik (1742—1820) carried out pioneer work in the practical development of agriculture on the Great Hungarian Plain, as well as in fodder crop cultivation, and the stabling system of animal husbandry. It was he who introduced alfalfa into Hungary, and he was also the initiator of up-to-date crop rotation, fruit growing, apiculture and silkworm breeding. The Hungarian Association of Agricultural Sciences awards the Sámuel Tessedik Medal, the work of László Solymári Valkó, for service to agriculture (Fig. 5). The obverse is taken up by a semicircular inscription: Tessedik Sámuel 1742—1820 Emlékérem (Sámuel Tessedik 1742—1820 Commemorative Medal), a portrait in left profile, the hall mark S/VALKÓ/960 and a date. On the reverse the emblem of the Hungarian Association of Agricultural Sciences, representing a microscope and an ear of wheat, and the inscription MAE are seen. The text of the circular inscription is: A Magyar Agrártudományi Egyesületben a szocialista mezőgazdaságért kifejtett kiváló tevékenységéért (For outstanding service in the Hungarian Association of Agricultural Sciences for socialist agriculture). The Hungarian Agricultural Museum was among the first to earn the medal; on the reverse of the specimen kept in its collection the following inscription is engraved: Országos Mezőgazdasági Múzeumnak 1960 (To the National Agricultural Museum 1960). The medal multiplied in cast bronze is 80 mm in diameter.

Fig. 1. Count György Festetics, obverse (author unknown). (Photo G. Kriss)

Fig. 2. János Nagyváthy, obverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 3. János Nagyváthy, reverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 4. Ferenc Pethe, obverse, the work of Ferenc Csúcs (Photo G. Kriss)

Fig. 5. Sámuel Tessedik, obverse, the work of László Solymári Valkó (Photo G. Kriss)

Fig. 6. Pál Vásárhelyi, obverse, the work of József Ispánki (Photo G. Kriss)

Fig. 7. Pál Vásárhelyi, obverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 8. Pál Vásárhelyi, reverse, the work of Walter Madarassy (Photo G. Kriss)

Pál Vásárhelyi (1797—1846), the most prominent hydraulic engineer of the reform period, was the designer of the Tisza river regulation and flood control system. He was the first to urge the investigation of problems concerning surface and ground waters on the Great Hungarian Plain. The plaquette bearing his name is awarded in three grades for excellent work in the field of water management. Among the designs entered for the competition, that presented by József Ispánki, the renowned Hungarian medallist, was accepted (Fig. 6). On the obverse of his work the eponym is represented in left profile in a recessed field, with the inscription: Vásárhelyi Pál — Díj (Pál Vásárhelyi — Award) above, A Reformkor / nagy vízimérnöke 1797—1846 (The great hydraulic engineer of the reform period 1797—1846) below, and fokozat (grade) indicated in Roman numerals in the centre. The plaquette is a horizontal rectangle; on the reverse is the inscription: Magyar hidrológiai / Társaság (Hungarian Hydrological Society); below this is a space where the name of the award-holder is engraved; then comes the continuation of the inscription: Részére / A vízgazdálkodás terén / kifejtett kiemelkedő / tevékenységéért (for excellent work in the field of water management), followed by the text giving the specific reasons for the award, with a branch of laurel on either side. The cast bronze plaquette is 67×100 mm.

Walter Madarassy's Vásárhelyi Medal was made on the artist's own decision. The manner of expression was not influenced by any stipulations. This fact resulted in a portrait full of character, drawn after a freely chosen model, and in a liberal design on the reverse, which brilliantly illustrates Pál Vásárhelyi's greatest merit (Fig. 7). On the obverse, a portrait represented in left profile is surrounded by the inscription Vásárhelyi Pál 1797—1846, with an MW hall-mark on the right (Fig. 8). On the reverse, in the middle of the field, a hand extended from behind a dike-wall prevents the water foaming and surging in the foreground from flooding a group of cottages behind. The inscription A reformkor / Nagy vízimérnöke (The great hydraulic engineer of the reform period) is placed along the edge of the medal, and the hall-mark MW on the right. among the houses. The cast bronze medal, 90 mm in diameter, is of an irregularly circular shape. (In the author's collection.)

Sándor Cserháti (1832—1909), plant breeder, was the founder of scientific plant production in Hungary. It was on his initiative that the National Experimental Station for Plant Production was established in 1891, of which he was the head right up to his death. The prize medal bearing his name is awarded to those who excel in plant production. The medal is the work of András Kiss Nagy, Kossuth Prize-winning sculptor. On the obverse, the eponym's portrait, the inscription: Cserháti Sándor Emlékérem (Sándor Cserháti Commemorative Medal) and the dates 1832—1909 are seen. The circular legend giving reasons for the bestowal: A MAE növénytermesztők társaságában kifejtett tudományos társadalmi munkáért (For scientific social work in the Plant Growers' Society of the Hungarian Association of Agricultural Sciences), an emblem with the inscription MAE (Hungarian Association of Agricultural Sciences), and a five-pointed star between an oak and a laurel branch are placed on the reverse. The medal is 78 mm in diameter and is made of cast bronze.

Géza Horváth (1847—1937), zoologist and academician, takes the credit for the successful fight against phyloxera in Hungary. In 1880 he was charged with the task of organizing the National Phyloxera Experimental Station. As an internationally acknowledged expert he was a member of several foreign scientific societies and published a large number of papers in English, French, German, Italian and other languages. On the obverse of the medal, awarded for achievements in plant protection, Géza Horváth was portrayed full-face by Sándor Kiss, a prominent Hungarian medal-maker. The portrait is surrounded by the inscription: Horváth Géza 1847—1937 Emlékérem (Géza Horváth 1847—1937 Commemorative Medal). On the reverse the emblem MAE and the five-pointed star between laurel and oak branches are found inside the circular legend: A MAE növényvédelmi társaságában kifejtett tudományos / társadalmi / munkáért (For scientific / social / work displayed in the Plant Protection Society of the Hungarian Association of Agricultural Sciences). The 70 mm medal is made of cast bronze.

Péter Treitz (1866—1935), agrogeologist, was the founder of agricultural soil science in Hungary. The method of soil mapping that he elaborated with his colleagues has been adopted by foreign agrogeologists as well. His successful work received wide international recognition, particularly after the first international agrogeological congress held in Budapest in 1909, in the organization of which he himself played an important role. He also dealt with the amelioration of alkali soils and investigated the possibility of growing grapes and tobacco on such soils. The medal bearing his name and portrait, awarded to those excelling in soil research, is the work of the Eminent Artist, András Kiss Nagy. On the obverse the inscription: Treitz Péter 1866—1935 Emlékérem (Péter Treitz 1866—1935 Commemorative medal) is placed right and left of the portrait. On the reverse the Association's emblem, the five-pointed star between laurel and oak branches, is seen inside the circular legend: A MAE talajtani társaság-

ban kifejtett tudományos társadalmi munkáért (For scientific social work displayed in the Soil Science Society of the Hungarian Association of Agricultural Sciences) giving reasons for the bestowal. The medal is 78 mm in diameter and of cast bronze.

Ferenc Hutyra (1860—1934), physician and veterinary surgeon, was Rector of the Veterinary College for a long time and developed it into an up-to-date scientific institution. The discovery of an anti-swine fever serum is linked with his name. He also elaborated a method of practical serum production. The medal bearing the portrait of the world-famous veterinary is awarded by the Hungarian Association of Agricultural Sciences for outstanding work in agriculture László Solymári Valkó, painter and sculptor, was requested by the Association to design the medal. The portrait on the obverse shows the great veterinary in right profile; along the edge of the medal there is a semi-circular inscription: Hutyra Ferenc Emlékérem (Ferenc Hutyra Commemorative Medal) and on the left the hall-mark S / Valkó / 60 and a date (1960). On the reverse the circular legend: A Magyar Agrártudományi Egyesületben a szocialista mezőgazdaságért kifejtett kiváló tevékenységért (For excellent work in the Hungarian Association of Agricultural Sciences for socialist agriculture) expresses the purpose of the medal, together with the Association's emblem and the five-pointed star between laurel and oak branches. The cast bronze medal is 80 mm in diameter.

The scientific and educational work of József Marek (1868—1952), Kossuth Prize-winning academician, made his name internationally known. The books he wrote, some with Ferenc Hutyra as co-author, were published in many widely-spoken languages. The drug he discovered for liver fluke won him international recognition. He was the first to demonstrate neurolymphomethosis in chickens; this disease was named after him abroad (Marek's disease). It is this part of his work which is emphasized on the reverse of the medal made by Walter Madarassy, the prominent Hungarian medal-maker (Fig. 9). The recessed field of the obverse contains a right profile portrait, with the inscription Dr. Marek József 1868—1952, and the hall-mark MW below the neck (Fig. 10). On the reverse a cock with diseased legs is surrounded by the inscription: Neuroencephalomyelitis / Enzootika / Gallinarum (Neuroencephalomyelitis / enzootic / of gallinaceae). The irregularly circular cast bronze medal is 84—87 mm in diameter. (In author's collection.)

The University of Veterinary Sciences has also paid respect to its famous late professor by a commemorative medal. The impressive medal is the work of the sculptor Walter Madarassy. The brilliant plastic portrait on the obverse, unlike the other medal representing József Marek described above, shows the left profile of the world-famous researcher of animal pathology. The inscription, hall-mark and dates: Dr Marek József 1868 MW 1952 provide the portrait with a discontinuous frame. On the reverse the representation of a serpent on an old open book, with the date 1787 below it (the year of foundation) and the circular legend: Universitas Scientiarum Veterinariarum (University of Veterinary Sciences) express his relationship with the university. The irregular circular cast bronze medal is 90—87 mm in diameter.

Imre Ujhelyi (1866—1923) was one of the theoretical and practical founders of up-to-date cattle farming in Hungary. He was the iniiiator of the modern preventive measures against tuberculosis. For some time he was the director of the Agricultural Academy at Magyaróvár. The prize medal issued by the Ministry of Agriculture and Food (Fig. 11), with his name and right profile portrait on it, has the inscription and dates: Ujhelyi Imre 1866—1923 and the hall-mark CS (Lajos Cséri). The reverse of the medal is left intact; it is here that the inscriptions giving reasons for the bestowal will be engraved: *a)* A / szarvasmarha tenyésztés / és törzskönyvezés/ érdekében kifejtett / eredményes / munkájáért (For fruitful work in cattle breeding and registration); *b)* Az élelmiszeripar / fejlesztése érdekében / kifejtett eredményes / munkájáért (For fruitful work in the development of the food industry). One specimen of each variant is preserved in the medal collection of the Agricultural Museum.

Imre Ujhelyi's excellence is also witnessed by the prize medal made by Sándor Rétfalvi, a sculptor from Pécs and instructor at the local secondary school for fine arts, whose hall-mark RS is engraved on the medal (Fig. 12). The 3/4 side-face portrait looking to the left is framed by the following circular legend: Ujhelyi Imre 1866—1923 + Iskoláért + Mezőgazdaságért + Szentlőrinc. (Imre Ujhelyi 1866—1923 + for education + for agriculture + Szentlőrinc). The one-sided cast bronze medal is 100 mm in diameter. (In the author's collection.)

Oszkár Wellmann (1876—1943), academician and university professor, was head of the Animal Breeding Department of the Veterinary College from 1910 up to his death. His work made a great contribution to the upswing of animal breeding in Hungary. It was he who initiated the widespread introduction of a more rational method of feeding, and, by elaborating an up-to-date system of cattle registration, a better method of selecting for breeding. Many of his works on the subject of animal breeding and feeding are of pioneer character; some of his standard works also appeared in German. His achievements excited interest even

Fig. 9. József Marek, obverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 10. József Marek, reverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 11. Imre Ujhelyi, obverse, the work of Lajos Cséri (Photo G. Kriss)

Fig. 12. Imre Ujhelyi, obverse, the work of Sándor Rétfalvi (Photo G. Kriss)

beyond the borders of Hungary. He was deservedly chosen as their example by those engaged in studies on animal breeding. Among them are those who receive the medal named after him as a reward for their outstanding scientific work. The obeerse of the medal contains the eponym's profile portrait, the inscription: Wellmann Oszkár 1876—1943 Emlékérem (Oszkár Wellmann 1876—1943 Commemorative Medal), the hall-mark S / Valkó / and the year the award was founded: 1973. The medal is the work of László Solymári Valkó. The reverse bears the circular legend giving the reason for the bestowal: A MAE Állattenyésztők Társaságában Kifejtett Tudományos Társadalmi Munkáért (For scientific social work in the Animal Breeders' Society of the Hungarian Association of Agricultural Sciences) as well as the emblem, the five-pointed star between oak and laurel branches, with the inscription: MAE. The cast bronze medal is 80 mm in diameter.

Rezső Manninger (1890—1970) academician, twice a winner of the Kossuth Prize, was a scholar of epizootics who was known all over the world. He organized and was for a long time head of the National Institute for Animal Hygiene. For some time he was Rector of the University of Agricultural Sciences, and later president of the Agricultural Section of the Hungarian Academy of Sciences, too. It is thus not surprising that his prominence is testified to by as many as three commemorative medals. The obverse of the first medal, made during his lifetime, bears a portrait of the eminent scientist framed by the circular inscription: Manninger Rezső professzornak nagyrabecsüléssel a phylaxia állatorvosai 1963 (To Professor Rezső Manninger with high esteem The Phylaxia veterinaries 1963). On the reverse the figure of a man with a pen and scroll in his hand can be seen, and with smaller figures, the scientist's pupils, behind it on either side. The representation is emphasized by the motto surrounding it: "Felix qui potuit rerum cognoscere causas" (Happy is he who can recognize the causes of things). The ∅ 83 mm cast bronze medal is the work of the medal-maker Professor József Reményi. (Dr. Gyula Varannai's collection. Az Érem, 1963, No. 26.)

The second Manninger-medal was made by István Martsa in 1974. The distinguished professor of sculpture was requested to make the medal by the Hungarian Microbiological Society as a memorial to their late president. On the obverse the full-face, bespectacled portrait, a brilliant plastic representation of the scientist, and the hall-mark M.I. are placed. The reverse is taken up with the inscription Manninger Rezső 1890—1970. The cast bronze medal is 70 mm in diameter.

The third Manninger-medal, the work of Sándor Tóth, sculptor, was commissioned by the National Institute of Animal Hygiene and multiplied by the State Mint (Fig. 13). On the obverse the bespectacled portrait (head and shoulders) of the founder of the Institute is seen. The inscription Manninger Rezső 1890—1970 is placed in a semi-circle above the portrait; the hall-mark (Tóth S.) and the year when the medal was made (1978) are on the right. On the reverse the inscription: Országos Állategészségügyi Intézet (National Institute of Animal Hygiene), the frontal picture of the Institute's central building, and the dates below: 1928—1978 refer to the establishment of the Institute half a century earlier; the silver patinated ∅ 40 mm medals made of tomback were distributed among the staff of the institute. (In the author's collection.)

Tamás Kosutány (1848—1915), agrochemist, was among those who initiated and urged the use of fertilizers in Hungary. He also carried out outstanding work on the scientific examination of the quality of Hungarian wheat and flour. He founded and was for a while editor of the journal "Mezőgazdasági Szemle" (Agricultural Review). A medal awarded by the Hungarian Scientific Society of the Food Industry for outstanding social work in the Society bears his name and portrait. Ferenc Csucs, a prominent Hungarian sculptor, was commissioned to design the medal (Fig. 14). On the obverse the inscription Dr Kosutány Tamás, the hall-mark CS, and the right profile portrait of the versatile scholar of nutrition science are seen. The reverse contains an emblem representing a torch, and the inscriptions: A Társadalmi Munkáért (For social work), and MÉTE (abbreviation of the Hungarian Scientific Society of the Food Industry). The cast bronze medal is 75 mm in diameter.

Elek Sigmond (1873—1939), academician and agrogeologist, who laid the foundations of modern soil research in Hungary, was an internationally recognized expert on soil science, and one of the founders of the International Soil Science Association. He organized the soil laboratories, the soil analysis system and the practical application of scientific results, and elaborated a system of classifying soils according to their suitability for agricultural utilization. Since 1956 the Hungarian Scientific Society of the Food Industry has annually awarded prize medals to those doing outstanding scientific work within the framework of the Society. The medal was made by Ferenc Csúcs (Fig. 15). His hall-mark CS is engraved on the obverse of the medal together with the inscription: Sigmond Elek dr and the eponym's left profile portrait. The reason for the bestowal: the inscription a Tudományos Munkáért (for scientific

work), the emblem with the torch and the inscription MÉTE are placed on the reverse. The cast bronze medal in 75 mm in diameter.

János Mathiász (1838—1921) was a vine breeder; some of his varieties were grown all over the world. He acieved considerable results in breeding wine-grapes, and gained world-wide fame with his dessert wines grown on lowland sands. It is particularly to his credit that he promoted the breeding of vines in Hungary and the production of grapes for eating on the drift-sand of the region between the Danube and the Tisza. The commemorative medal made by Ferenc Csucs for the fiftieth anniversary of his death helps to recall the undying merits of the Hungarian pioneer of grape-vine breeding (Fig. 16). On the obverse, the inscription and dates: Mathiász János 1838—1921 surround the left profile portrait; below the neck the hall-mark Csucs can be seen (Fig. 17). On the reverse, grape-vines richly loaded with fruit are a reference to János Mathiász' excellent work; the date 1971 gives the time when the medal was made. The cast bronze medal is 78 mm in diameter.

Mátyás Mohácsy (1881—1970), Kossuth Prize-winning horticultural engineer and doctor of agricultural sciences, was head of the Fruit Growing Department and, at one time, Rector of the University of Horticulture. He was president of several professional committees and advisory bodies, as well as of the National Society of Horticulturists. It was he who initiated the development of the Horticultural Research Institute, and laid the foundation of research which promoted commercial fruit production in Hungary. Considering his merits, it was not by mere chance that the Hungarian horticulturists chose him as their ideal. The Horticultural Society functioning within the framework of the Hungarian Association of Agricultural Sciences established a commemorative medal bearing his name and portrait to award to those who proved best in this field. On the obverse, the left profile portrait is framed by the circular inscription: Mohácsy Mátyás 1881—1970 Emlékérem (Mátyás Mohácsy 1881—1970 Commemorative Medal). It is the work of the sculptor Iván Szabó, Professor of the Academy of Fine Arts, who placed his hall-mark SZI on the obverse. On the reverse a circular legend is found, giving the reason for the bestowal: A MAE Kertészeti Társaságában Kifejtett Tudományos Társadalmi Munkájáért (For scientific social work in the Horticultural Society of the Hungarian Association of Agricultural Sciences/; this surrounds the Association's emblem, the blank area where the name of the award-holder will be engraved and the five-pointed star. The cast bronze medal is 77 mm in diameter.

Mátyás Mohácsy was also commemorated on the medal made on the occasion of the Academic Horticultural Days organized on the State Farm of Zala in 1970. The medal was created by Sándor Kiss, sculptor, who represented the great pomologist full-face (Fig. 18). Above the portrait the inscription referring to the occasion: Akadémiai Kertészeti Napok Zala (Academic Horticultural Days Zala), in the middle, right and left: ÁG. (the abbreviation for State Farm) and 1970, and below this, right and left: Mohácsy Mátyás, with the hall-mark KS placed between the surname and forename. The one-side cast bronze medal is 110 mm in diameter. (In the author's collection.)

Jenő Vadas (1857—1922), a forestry engineer who wrote a great deal on the subject of forestry, lectured on forest cultivation and protection, botany and zoology at the Academy of Mining and Forestry. He was the first head of the Central Forest Research Station he himself had organized and was later president of the International Union of Forest Research Stations. He was the editor of the journal "Erdészeti Kísérletek" (Forestry Experiments) which he founded. His works "Az árvízvédelmi füzesek telepítése és művelése" (Plantation and cultivation of anti-inundation willow groves) and "Az akácfa monográfiája" (Monograph of Robinia) were published in French, and the latter also appeared in German. His name and work are preserved by two medals: a commemorative medal and a prize medal; both are the works of Walter Madarassy, sculptor, and show the same portrait and the same inscription on the obverse (Fig. 19). The inscription Vadas Jenő is placed above the portrait, represented in left profile, and below it the dates 1857—1922 and the hall-mark M are seen. The reverses (Fig. 20) are similar — a crouching figure measuring a young pine-tree, with a pen in his hand and a note-book in his lap, and the hall-mark MW to the left of the figure — except that the inscription on one of them is Erdészeti Tudományos Intézet (Scientific Institute of Forestry) 1898 (the year of foundation), while on the other, which is bestowed as an award it reads; Erdészeti kutatás fejlesztéséért (For developing forest research). The cast bronze medals are of identical size: 82 mm in diameter.

Gusztáv Szabó (1879—1963), mechanical engineer, professor at the Technical University, was a leading figure in the mechanization and technical development of Hungarian agriculture. He was for a long time professor of agricultural mechanics and head of the Institute for Agricultural Machine Experiments. The commemorative medal named after him is granted as an acknowledgement of scientific work in the Mechanization Society of the Hungarian Association of Agricultural Sciences. On the full-face portrait on the obverse of the

Fig. 13. Rezső Manninger, obverse, the work of Sándor Tóth (Photo G. Kriss)

Fig. 14. Tamás Kosutány, obverse, the work of Ferenc Csúcs (Photo G. Kriss)

Fig. 15. Elek Sigmond, obverse, the work of Ferenc Csúcs (Photo G. Kriss)

Fig. 16. János Mathiász, obverse, the work of Ferenc Csúcs (Photo G. Kriss)

Fig. 17. János Mathiász, reverse, the work of Ferenc Csúcs (Photo G. Kriss)

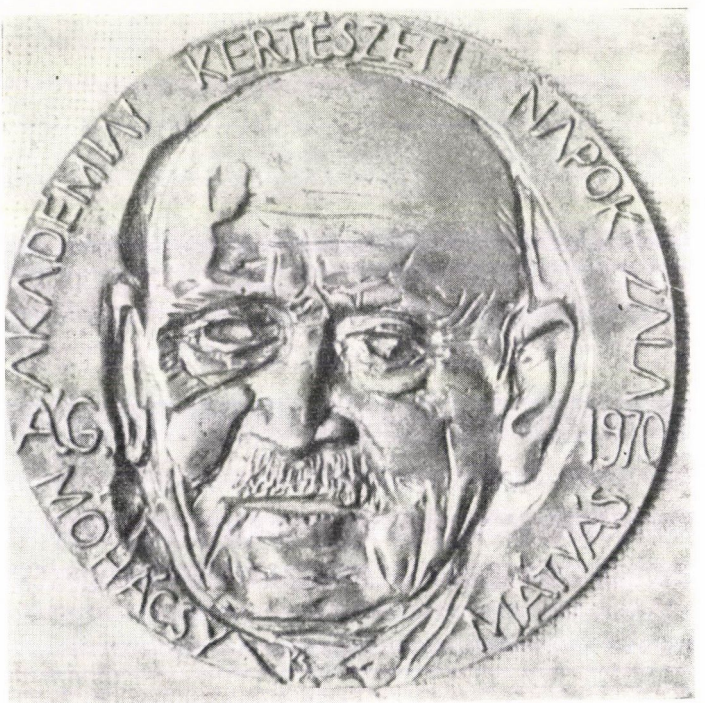

Fig. 18. Mátyás Mohácsy, obverse, the work of Sándor Kiss (Photo G. Kriss)

Fig. 19. Jenő Vadas, obverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 20. Jenő Vadas, reverse, the work of Walter Madarassy (Photo G. Kriss)

Fig. 21. Ottó Herman, obverse, the work of Mária Osváth (Photo G. Kriss)

Fig. 22. Iván Balassa, obverse, the work of Ferenc Csúcs (Photo G. Kriss)

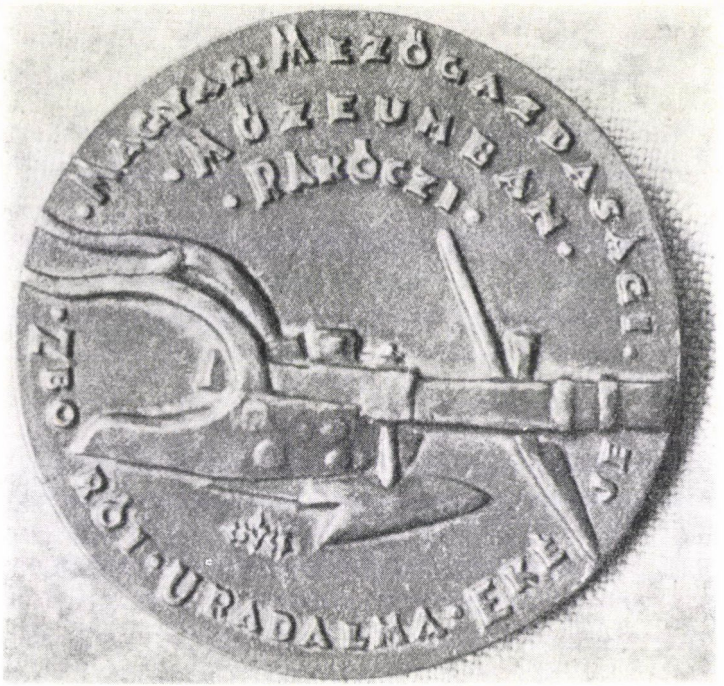

Fig. 23. Iván **Balassa**, reverse, the work of Ferenc Csúcs (Photo G. Kriss)

Fig. 24. Beethoven—Brunszvik, the work of László Csontos (Photo G. Kriss)

medal he is represented by the sculptor Sándor Kiss with the rector's chain of office round his neck, a reference to his post as rector of the Technical University. The inscription reads: Szabó Gusztáv Emlékérem 1879—1963 (Gusztáv Szabó Commemorative Medal 1879—1963) and KS, the hall-mark. The reverse contains a circular legend giving the reason for the bestowal: MAE Gépesítési Társaságában Kifejtett Tudományos Társadalmi Munkáért (For scientific social work in the Mechanization Society of the Hungarian Association of Agricultural Sciences), the emblems with the inscription MAE, and the five-pointed star with laurel and oak branches. The cast bronze medal is 70 mm in diameter.

The name of Ottó Herman (1835—1914), natural scientist and ethnographer, is linked with the establishment of the Hungarian Ornithological Centre. Most of his wide-ranging scientific work was connected with agriculture, as shown by his works "A magyar halászat könyve" (Fishing in Hungary), "A halgazdaság rövid foglalatja" (A brief summary of fish management), "Az ősfoglalkozások: Halászat és pásztorélet" (Primaeval occupations: Fishing and shepherding), and "A madarak hasznáról és káráról" (Good and harm done by birds), to mention only the best known ones. On the medal made by Mária Osváth his work with birds is emphasized (Fig. 21). On the left of the hatted full-face portrait there is a bird sitting on a branch, and it is here that the hall-mark OM and the year 1975, when the medal was made, are placed, too. The inscription Herman Ottó and the dates 1835—1914 are above the portrait, on the right. The one-sided cast bronze medal is 143 mm in diameter. (In the author's collection.)

Iván Balassa (1917—), ethnographer, is a prominent scholar of the ethnography of agriculture in Hungary. A large part of his manifold scientific work is also conczrned with the history of agriculture. With his works "A magyar kukorica" (Hungarian maize), "Földművelés a Hegyközben" (Tillage in Hegyköz), and last but not least "Az eke és a szántás története Magyarországon" (History of the plough and ploughing in Hungary) he greatly contributed to investigations into the history of agriculture in Hungary. Since 1966 he has been deputy director-general of the Agricultural Museum, and between 1969—1971 was vice-president of the International Organization of Agricultural Museums. The medal bearing his portrait is the work of the sculptor Ferenc Csucs (Fig. 22). The left profile portrait, the inscription Balassa Iván and the date 1976, when the medal was made, are placed on the observe. The old plough represented on the reverse, a reference to one of Iván Balassa's main works, is emphasized by the legend: Magyar Mezőgazdasági / Múzeumban / Rákóczi / Zborói Uradalma Ekéje (The plough of Rákóczi's Zboro estate in the Hungarian Agricultural Museum), which, together with the hall-mark Csucs, surrounds the plough (Fig. 23). The cast bronze medal is 100 mm in diameter. (In the author's collection.)

Ferenc Erdei (1910—1971), academician, agroeconomist and sociographer, was president of the Research Institute of Agricultural Economics of the Hungarian Academy of Sciences. He was one of those who supervised the execution of the land distribution act, and later propagated co-operative farm management. For a while he was also Minister of Agriculture. In the second half of his life he dealt with questions of agricultural policy and organization science. His prominent work is called to mind by the commemorative medal established by the Society of Agricultural Economics and made by the sculptor Iván Szabó, who was on friendly terms with Ferenc Erdei. The good likeness on the obverse is framed by the circular legend: Erdei Ferenc 1910—1971 Emlékérem (Ferenc Erdei 1910—1971 Commemorative Medal). Below the prtrait the hall-mark SZI is seen. The arrangement of the reverse is similar to the other medals of the Hungarian Association of Agricultural Sciences; it contains the circular legend giving the reason for the bestowal: A MAE Agrárgazdasági Társaságában Kifejtett Tudományos Társadalmi Munkáért (For scientific social work in the Society of Agricultural Economics of the Hungarian Association of Agricultural Sciences), the emblem with the inscription MAE, the blank space where the name will be engraved, and the five-pointed star between laurel and oak branches. The cast bronze medal is 77 mm in diameter.

After this account of medals connected with the great characters of Hungarian agriculture mention should also be made of a commemorative medal quite unlike the others. It is included here because one of the figures in the dual portrait represents Ferenc Brunszvik, who was a prominent personality of his time and also of the agriculture of Hungary at the beginning of the 19th century. The other portrait needs some explanation, however, as it represents Beethoven, one of the greatest figures in the universal history of music.

The name of Ferenc Brunszvik (1777—1849) is known to posterity mainly due to his friendship with Beethoven. The great musician was on occasion his guest on his Martonvásár estate. Ferenc Brunszvik, however, was not only a music-lover but also an "excellent farmer", who developed his lands at Martonvásár into a model estate within a short time. On the basis of experience gained abroad he introduced "rational" farm management, began to grow fodder crops and rear improved sheep breeds. In a description by the English doctor Richard Bright,

which dates from 1815, the management of Ferenc Brunszvik's estate was considered worthy in many respects of emulation. At present the larger part of the manor-house at Martonvásár is occupied by the Agricultural Research Institute of the Hungarian Academy of Sciences, while a section of the building is reserved for the Beethoven Memorial Museum, as a reminder of the great composer's prolonged stay there. In the beautiful park grandiose Beethoven concerts are organized in summer with the participation of famous conductors and performers. The research institute, which produces internationally recognized research results in this impressive milieu, regards it as a duty to cultivate the traditions of the place, as attested by the commemorative medal made in 1982 by the sculptor László Csontos, a prominent Hungarian medal-maker, who was commissioned by the Institute (Fig. 24). The two full-face portraits, placed side by side, are framed by the circular legend: ..Beethoven..Brunsvik F...Martonvásár..; the hall-mark CSL is seen on the left. The one-sided cast bronze medal is 110 mm in diameter.

Those medals for which no information is given as to where they are kept, can be found in the Hungarian Agricultural Museum or at the institute or society which issued them.

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CONTRIBUTIONS

WATER UTILIZATION IN AGRICULTURE*

Mankind is the common result of an interaction between nature and society. Society can only exist in nature and dependent on nature. Materials, energy sources and other conditions of life are indispensable to the survival and prosperity of the human race and society. Nature, however, previously existed and could exist in the future without humanity and society.

Forests and arable lands cover 87% of Hungary's surface. The natural resources existing on this territory, in the atmosphere and in the hydrological cycle represent our basic national heritage.

The utilization of water resources, as the main goal and form of water use in agriculture may correspond with the interests of the entire human society connected to the present and the future economy if it is carried out in harmony with other natural resources affecting agriculture.

Agricultural water utilization is carried out in a unique process with the land use on the given territory. At the same time water utilization cannot be separated from regional and local water management measures. Finally it is in interaction with all regulative measures, such as reclamation and environmental control.

Water utilization is a very complex process. This feature characterized the ancient Inca or Mesopotamian water and land use as well as that of the present. The decay of these civilizations may be attributed to a failure to acknowledge damaging effects, which could therefore not be hindered or even transformed.

A number of fields of science are interested in the more exact exploration of the laws of agricultural water utilization.

Significant and many-sided results have been achieved within the scope of agricultural water utilization during the last 10—15 years. This is partly the reason for an partly the consequence of the considerable progress achieved in water management and in agriculture.

The rapid, broad transformation of the world, of national economics and of the ecological environment, however, are preparing new and important alterations in the field of water utilization, as elsewhere. First of all it is science which has to react to these, but subsequently practical farmers must also respond.

Several thoughts will be explained here on the basis of the principles and viewpoints mentioned above, in order to demonstrate the character and complexity, as well as the magnitude of these problems.

Water can be considered as the most peculiar factor among the four natural factors (light, heat, air and water) which are bioecologically of equal importance. This is so because, on the one hand, the lack or harmful excess of water resources in the vegetal space places strong limits on the effectivity of crop cultivation over the greater part of the country in most years, and on the other hand because it can be regulated (increased or decreased) most easily in both space and time, although this necessitates increasing social investments.

The role and place of forests and arable land in the absorption, transformation and discharge of water have not been sufficiently explored. The research carried out so far is significantly inferior to both the possibilities and the great interests of our society.

The overwhelming part of the water utilized in agriculture is used up by crop cultivation.

Below, not underestimating the requirements of husbandry, fish-breeding, etc., the basic problems of water utilization in crop cultivation will be dealt with.

* Contribution at the common department session of the Hungarian Academy of Sciences after the lecture held by academicians M. Pécsi, P. Stefanovits and F. Martos on Utilization Possibilities of the Environment of Human Society.

I

Precipitation on arable lands — the rate of usable and utilized precipitation in Hungary

Partly quantitative and partly qualitative questions emerge when considering water utilization from ecological or crop production viewpoints. The examinations must be carried out separately for the irrigated and non-irrigated territories of Hungary.

Non-irrigated territories represent more than 80% of the 87% of forestal and arable lands in Hungary. Of this 72% is covered by arable land.

The water balance processes of non-irrigated territories are the determinants of forest and land cultivation.

Strictly speaking — in the case of arable land — four quantitative characteristics can be underlined as follows:

(i) the quantity of precipitation falling onto the given territory (Cs_1),
(ii) efficiency of precipitation, i.e. the quantity of rainfall remaining on the territory (Cs_2),
(iii) precipitation actually utilized (Cs_3), and finally,
(iv) production and ecological efficiency of utilized precipitation (Q).

The phenomena mentioned above, which characterize the water utilization under the production conditions on large scale farms, have not been measured together so far at the same spot with the same vegetation, although they have been investigated separately under different conditions for several decades.

Similarly, researchers have still not carried out water quality examinations on the quality changes in the water arriving onto the field via precipitation or irrigation and the which runs off it.

An attempt is made in the following to draw up estimated quantitative national water balance characteristics.

During the hydrometeorological year the quantity of precipitation can be estimated as 58 km³ in Hungary. Of this, about 50 km³ falls on forests and arable land (8.3 million ha).

It is worth mentioning that the amount of water arriving in the country in water courses is about 100 km³ during the same hydrometeorological year. The quantity of water falling on the arable land (approx. 6.7 million ha) may be estimated as 38—40 km³.

The water quantities listed below do not remain in the root-zone of the soil as utilizable moisture:

interception	4 km³
run-off	6—8 hm³
percolation	1 km³
evaporation outside the vegetation season	4—6 km³

Having subtracted the above quantities, the amount of water remaining in the root-zone may be estimated as about 22 km³. This quantity of water corresponds to about 320 mm precipitation, of which 260—280 mm falls on the Great Hungarian Plain. In 30% of the years it is significantly more than this and in another 30% it is significantly less. During these periods irrigation or drainage gain importance.

These data are, however, general values, which naturally means that on soils with high intake and water holding capacity the utilizable amount of precipitation may be considerably higher, while on other territories it may be lower.

Observations prove (L. Kreybig has published a large number of data) that precipitation stored up in the soil may be fully utilized in one place and only partially in another, depending on the crop and the soil. According to our estimations 0—15% of the water stored up in the soil may remain unutilized each year, and this phenomenon has the effect of modifying the balance of the next year.

In this way, according to our estimations, the water quantity falling as precipitation on to the arable lands of Hungary runs to 38—40 km³ in an average year. Of this about 22 km³ remains in the soil. The efficiency of precipitation is about 56%.

The water quantity actually used up, however, is about 20 km³. So about 50% of the precipitation is utilized in the process of evapotranspiration. An improvement in this efficiency could cover the water requirements of 400 000 t maize (grain) for every 1% — chiefly by means of mental and not financial investments.

A stricter examination of the effects of relief and exposure would also be important from this point of view.

The situation is rather different on irrigated lands. The quantity of irrigation water applied on half a million ha of irrigated land amounts to 1 km³ ($\ddot{O}Cs_1$). The water application

cannot be expected to reach more than double this quantity. But in the case of irrigated land the surplus of interception is as much as 4—6%, that of run-off 10—20%, and that of percolation 5—10%.

Thus only 70—75% of the irrigation water applied can be considered as a utilizable water resource. A certain proportion of this remains in the soil at the end of the vegetation season. So the water quantity actually used up (evapotranspiration) is less. The national average for this ($\ddot{O}Cs_3$) may be estimated as 60—70%.

Field measurements and records of these data should be kept on all farms on both irrigated and unirrigated land.

II

Ecological examination of irrigation capacities

Irrigation is a branch of agricultural water utilization that requires specific and separate examinations. The sum of state and farm investments in irrigation projects runs to as much as about 20 thousand million Ft. The national plans foresee a considerable increase in these investments.

The degree of exploitation of these investments is by no means a matter of indifference.

On behalf of and with the many-sided support of the Ministry of Agriculture and Food, examinations have been carried out relating to the exploitation of existing irrigation projects in farms. In 1978 the ecological index of this irrigation water intake capacity was examined in about 40 cases under given field and farm conditions. This index expresses the extent to which irrigation water requirements are covered, depending on weather, soil and crop.

The exploitation of irrigation water intake capacity has been found, on the basis of examinations on 40 farms in 1978, to be as follows:

Excess or lack of irrigation water (mm)

	East	Middle Hungary	West
Maize	—45	—117	—43
Sugarbeet	—95	—200	—190
Alfalfa	+25	—112	—23

The above data explain why yields are not satisfactory on lands equipped for irrigation.

20—50% exploitation of the technical capacities would have been necessary in 1978, but they were only 5—25% exploited.

III

Efficiency of water utilization in crop production

The most expressive biological index of the efficiency of water utilization is the efficiency of evapotranspiration in crop production. This can be given as the quantity of yield protein, biomass, energy, etc. per unit of water. This index includes

(i) environmental requirements of the crop cultivated and the yield to be reached;

(ii) ecological factors (exposure, soil-weather conditions, etc.) of the land used;

(iii) production technology, especially intensity of fertilization.

The efficiency index of water utilization expresses the farming level, i.e. not only the level of water utilization, but the degree of exploitation of the other natural and social resources as well. It may be adapted to compare the common level of biological, financial, natural environment and production technology factors for different years, crops and lands.

The examinations show that the following values may be considered as good. For example, in the case of maize, if 1 t grain is produced with 500—600 m^3 of water (yield level 6—10 t/ha); and in the case of sugarbeet, if 1 t root is produced with 90—100 m^3 water (yield level 45—88 t/ha).

IV

Conclusions

Several of the considerations and problems explained above should be emphasized. The following are thought to deserve increased attention both theoretically and practically as well as from the point of view of scientific management.

(i) Agricultural water utilization is an integral part of the economy of natural resources in farming, and is expressed in discovering, registering and regulating as well as forecasting the data of the Earth's surface in relation to the soil, the atmosphere and the hydrological cycle at a regional and national level.

(ii) It would be worthwhile concentrating on interdisciplinary investigations which could include simultaneous examinations of water quality and quantity in the same time and space dimensions during entire vegetation seasons or even hydrological years under large scale farming conditions.

(iii) The harmony between water utilization possibilities and land use could prove to be the biggest ecological reserve of Hungarian agriculture.

(iv) Research and practice of agricultural water utilization take place in the same complex system that includes ecological, technical, economical and political environments.

The successfulness of the work is derived from the positive interactions among these. A disadvantageous event in one of the sub-systems may deteriorate the effectiveness of the entire system.

A correct policy for discovering and adapting natural (ecological) possibilities is a primary and basic necessity.

The initiation of interdisciplinary research in the social and natural sciences would represent a progressive step forward.

I. PETRASOVITS

INFORMATIVE STATEMENTS ABOUT THE REQUIREMENTS OF NUTRIONAL ENERGY OF THE WORLD POPULATION, THE THEREFORE NECESSARY CEREAL EQUIVALENTS AND THE NUTRIENT WITHDRAWALS COMPENSATING NPK-AMOUNTS*

If Man is to have an adequate supply of food to guarantee his survival and to overcome the undernutrition, hunger and social misery still found in many countries of the earth, it is necessary in the following years, when the world population is expected to increase from the present 4 billion to about 6—7 billion in the year 2000, for the food production to be increased considerably. Also, the loss of harvested products by spoilage, pests, insects and rodents should be reduced in a complex manner. In many countries the proportional share of animal proteins in the daily rations must also be raised considerably.

There can be no doubt that in the near, or more particularly in the distant future, it will be possible

— for plant proteins to be transformed economically by modern physico-chemical processes into "animal-like proteins" of high nutritional quality;
— for different plant nutrients with low nutritional quality to be improved by chemical processes to create foodstuffs with high nutritional qualities;
— for proteins, carbohydrates, fats and vitamins to be produced from cultures of yeasts and algae, and also by the bacterial utilization of fuel, earth gas, industrial and communal wastes and sewage sludges, and
— for fish and other aquatic life to be used in a more intensive and rational way without exhausting the oceans, lakes and rivers.

But recognizing this, in the future agriculture, horticulture and forestry will also have a great responsibility to solve the very important task of not only producing enough food of high quality for the increasing world population, but in addition to produce much more raw materials for industrial production, in order to cover the increasing requirements of

* Contribution to the round table conference on Artificial Fertilization in the FORUM column of our journal Tomus 29 (1—2), pp. 117—225 (1980).

mankind and to replace the continually diminishing non-renewable resources of fossil fuels and "bound carbon". This means that besides food and fibre plants, so-called "energy plants" for the production of biogas and alcohols for car engines and various energy-consuming industrial processes, and later so-called "bound carbon plants" for the chemical and pharmaceutical industry, in order to produce plastics, elastic, drugs, synthetic fibres, etc. will also have to be cultivated, because they will play a very important and continually increasing role.

Therefore, up to the year 2000 and beyond, agricultural production as a whole and the crop yields per hectare of food plants in particular must be increased tremendously. Since cereals play a very important role in the nutrition of man and animals in all countries, in the following calculations the utilizable energy from cereals has been taken as the "compensating energy" for the "necessary nutritional energy of mankind". Therefore, it is of great interest to know how many tons of these crops must be produced an how many tons of plant nutrients are necessary.

If it is accepted that under these circumstances an adequate requirement of food energy for one person per day corresponds to a mean of 11 300 kJ (about 2700 kcal), 60% of which should be provided as plant and 40% as animal foodstuffs, the following figures may give a rough first-order approach, as a guideline for prognostic orientation and for planning future plant production, to the nutritional energy requirements and the necessary production of cereals or grain equivalents per person and for the whole world population, and, in addition, to the minimum mineral NPK-amounts compensating for nutrient withdrawals by the cultivated crops.

But taking in consideration the fact that at present an average of 25% of the harvested food is spoiled on a global scale by inefficient harvesting methods, during transport, or by pests, insects and rodents, the corresponding figures for cereal production and NPK-requirements must be increased by 25%.

Requirement per person		Worldwide requirements	
		in 1980	by 2000
		with a population of about	
		4 billion	6.5 billion
Daily energy requirement			
kJ	11,304	45.2×10^{12}	73.5×10^{12}
kcal	2,700	10.8×10^{12}	17.6×10^{12}
Nutritional energy requirement per year			
kJ	4.2×10^{6}	16.8×10^{15}	27.3×10^{15}
kcal	985,500		
i.e. approx.	1×10^{6}	4.0×10^{15}	6.5×10^{15}
of this, in the form of plant food (60%)			
kJ	25.12×10^{5}	10.1×10^{15}	16.3×10^{15}
kcal	6.0×10^{5}	2.4×10^{15}	3.9×10^{15}
in the form of animal food products (40%)			
kJ	16.8×10^{5}	6.7×10^{15}	10.9×10^{15}
kcal	4.0×10^{5}	1.6×10^{15}	2.6×10^{15}
Requirement of plant energy units for the production of these animal food products with a mean conversion index of 5 : 1			
kJ	8.4×10^{6}	43.2×10^{15}	70.2×10^{15}
kcal	2.0×10^{6}	10.4×10^{15}	16.9×10^{15}
Total requirement of plant energy units			
kJ	10.8×10^{6}	43.2×10^{15}	70.2×10^{15}
kcal	2.6×10^{6}	10.4×10^{15}	16.9×10^{15}

Requirement per person	Worldwide requirements	
	in 1980	by 2000
	with a population of about	
	4 billion	6.5 billion
Requirement of cereals or grain equivalents if the energy conversion factor is 14.65 kJ (3.5 kcal)/g cereals		
Metric tons	about 0.75	3.0×10^9	4.88×10^9
N-, P- and K-withdrawals from the field by the amount of cereals necessary to compensate for the food energy requirements of Man		
N	22.5 kg	90.0×10^6 t	146.25×10^6 t
P	4.3 kg	17.2×10^6 t	27.95×10^6 t
K	14.9 kg	59.6×10^6 t	96.85×10^6 t
Total NPK	41.7 kg	166.8×10^6 t	271.05×10^6 t
To compensate for 60% of the N-, P- and K-withdrawals in the form of mineral fertilizers if 40% is compensated for by NPK nutrients in stubble and other plant refuse and in animal manure		
N	13.50 kg	54.0×10^6 t	87.75×10^6 t
P	2.58 kg	10.3×10^6 t	16.77×10^6 t
K	8.94 kg	35.8×10^6 t	58.11×10^6 t
Total NPK	25.05 kg	100.1×10^6 t	162.63×10^6 t
Effective yearly mineral NPK-requirements to compensate for the nutrient withdrawals by crops if a utilization quotient of 70% is calculated for N and K and 50% on a long-term scale for P		
N	19.28 kg	77×10^6 t	125×10^6 t
P	5.16 kg	21×10^6 t	34×10^6 t
K	12.77 kg	51×10^6 t	83×10^6 t
Total NPK	37.21 kg	149×10^6 t	242×10^6 t

Energy requirements for production, transport and application of the necessary effective mineral NPK-fertilizers to compensate for the nutrient withdrawals by an energy requirement of 80,596 kJ (19,250 kcal) kg N^{-1}, 22,969 kJ (5,486 kcal) kg P^{-1} and 8,868 kJ (2,118 kcal) kg K^{-1}

N	1,553,891 kJ (371,140 kcal)
P	118,520 kJ (28,308 kcal)
K	113,244 kJ (27,047 kcal)
Total NPK	1,785,655 kJ (426,495 kcal)
N	$6,220\times10^{12}$ kJ ($1,480\times10^{12}$ kcal)
P	470×10^{12} kJ (120×10^{12} kcal)
K	450×10^{12} kJ (110×10^{12} kcal)
Total NPK	$7,140\times10^{12}$ kJ ($1,710\times10^{12}$ kcal)
N	$10,100\times10^{12}$ kJ ($2,410\times10^{12}$ kcal)
P	770×10^{12} kJ (190×10^{12} kcal)
K	740×10^{12} kJ (180×10^{12} kcal)
Total NPK	$11,610\times10^{12}$ kJ ($2,780\times10^{12}$ kcal)

Taking into consideration the 40% of retrograding NPK nutrients in stubbles, plant refuse and animal manure, the energetic utilization coefficient of the mineral fertilizer requirements to compensate for NPK withdrawals by crops will be 6.1. Even if the "retrograding organic fertilizer units" are ignored, this figure will still be 3.66.

Because 14.65 kJ (3.5 kcal) correspond in the mean to the energy equivalent of 1 g of cereals, 1 kJ (1 kcal) in the form of mineral fertilizer will produce 0.416 g (1.74 g) of grain if the "retrograding organic NPK nutrients" are considered. If these "retrograding organic NPK nutrients" are ignored 1 kJ (1 kcal) in the form of mineral fertilizer will produce 0.250 g (1.05 g) of grain.

The energy expense for the production, transport and application of every 1 kg N plus 1 kg P plus 1 kg K with a total energy content of 112,433 kJ (26,854 kcal) requires, for a corresponding "energy compensation", a production of

5.501 kg of grain with respect to N
1.567 kg of grain with respect to P
0.605 kg of grain with respect to K

i.e. a total of 7.672 kg, or a round figure of 8 kg of grain

If it is possible to use the straw or other plant refuse for a gain of utilizable energy, the production of less than 8 kg of grain or grain equivalents is necessary for energy compensation.

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LECTIONES

COMPARATIVE STUDY OF TABERSONINE PRODUCTION OF THE SHOOTS OF AMSONIA AND RHAZYA SPECIES*

Certain *Apocynaceae* species have, among other things, a tabersonine indole alkaloid content that may serve as a starting material for pharmaceutically interesting compounds. According to the literature (GILBERT 1965, ZSADON 1973) tabersonine accumulates in an exploitable quantity in the seeds of *Amsonia* and *Rhazya* species, but only in traces in the vegetative organs (ZSADON 1973, BÖJTHE-HORVÁTH *et al.* 1974, KOCSIS *et al.* 1974, KOCSIS *et al.* 1978). In the present paper the variation in the tabersonine content of old, mainly 15-year-old *Amsonia* and *Rhazya* populations is discussed, in order to gain preliminary information on whether differences exist between the alkaloid production of these taxa.

Five shoots were cut off monthly from about 60 populations of *Amsonia tabernaemontana* Walt., *A. angustifolia* Michx., *A. illustris* Woods, *A. salicifolia* (Pursh) Raf. and *Rhazya orientalis* A.D.C. during the 1980 vegetation period. The separated organs were

Table 1

Differences in the phytomass of Amsonia and Rhazya species

a) Weight per shoot (in g)

	Rhazya orientalis: $\bar{X} = 3.98$			
	$\bar{X}$	dt	P%	LSD
A. tabernaemontana	7.29	85	1	3.26
A. angustifolia	7.26	214	1	3.30
A. illustris	6.99	152	5	3.00

b) Weight of follicles per shoot (in g)

	Rhazya orientalis: $\bar{X} = 0.76$			
	$\bar{X}$	dt	P%	LSD
A. tabernaemontana	1.46	124	10	0.59
A. angustifolia	1.80	175	1	0.88
A. illustris	1.38	68		

* Paper presented at the 1st International Conference on Chemistry and Biotechnology of Biologically Active Natural Products, Varna, Bulgaria, September 22—26th 1981.

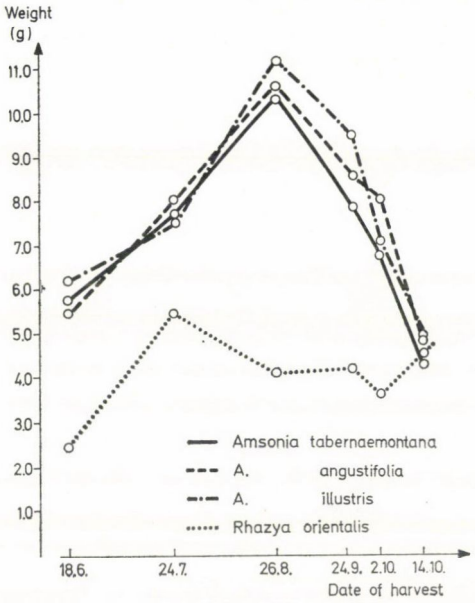


Fig. 1. Variation in shoot phytomass during the vegetation period

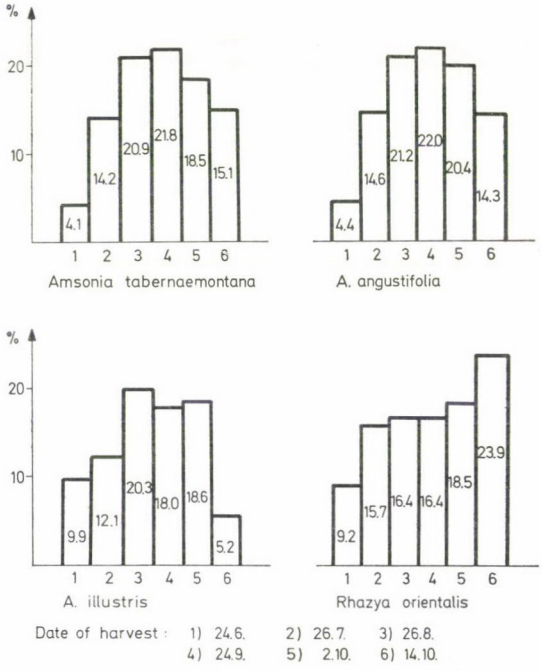


Fig. 2. Changes in the proportion (dry wt.) of generative organs in the shoots

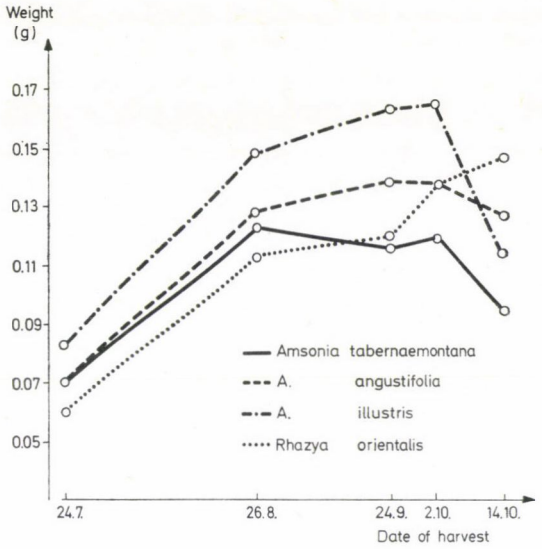
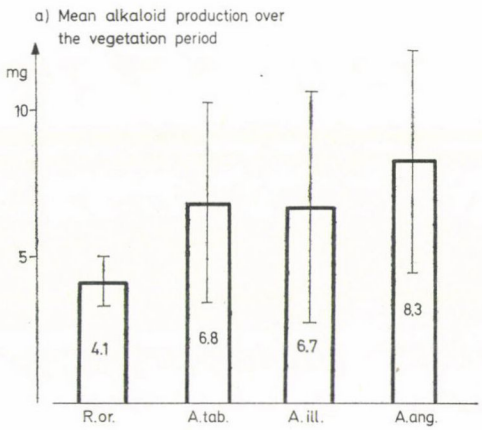


Fig. 3. Changes in the weight of follicles during the vegetation period



b) LSD of the above means

	R.or.	A.tab.	A.ill.	A.ang.
R. or.	–	Ø	Ø	3.14
A. tab.	Ø	–	Ø	1.45
A. ill.	Ø	Ø	–	1.33
A. ang.	++	++	+	–

++ P = 5 % ; + P = 10 %

Fig. 4. Annual alkaloid production of shoots harvested monthly

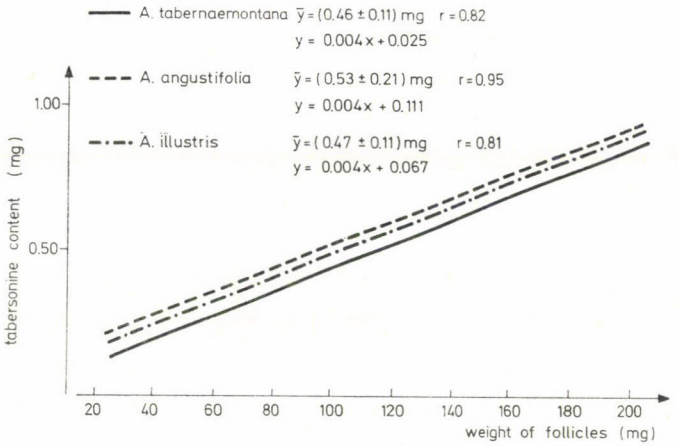


Fig. 5. Tabersonine production of Amsonia follicles as functions of follicle weight

Table 2

Average alkaloid content (dry wt.%) of Amsonia species and Rhazya orientalis

		Follicles			seeds	
		$\bar{x}$	±s	r*	$\bar{x}$	±s
Amsonia illustris	a	1.30	0.31	—0.93		
	b	1.08	0.22	—0.99	1.10	0.21
	c	0.47	0.11	—0.91	0.72	0.33
A. angustifolia	a	1.36	0.36	—0.92		
	b	1.20	0.28	—0.91	1.23	0.28
	c	0.53	0.05	—0.94	0.81	0.28
A. tabernaemontana	a	1.69	0.26	—0.97		
	b	1.21	0.25	—0.99	1.31	0.27
	c	0.48	0.08	—0.93	0.76	0.21
A. salicifolia	a	1.72	0.29	—0.88		
	b	1.32	0.34	—0.90	1.40	
	c	0.47	0.06	—0.48	0.82	
Rhazya oerientalis	a	1.53	0.34	—0.57		
	b	1.21	0.32	—0.96	1.17	0.28
	c	0.51	0.11	—0.79	0.79	0.18

a: total; b: with "α-methylene-indoline moiety"; c: tabersonine.
* Alkaloid content as the function of number of days from the appearance of the follicles

weighed after drying at 80 °C. The alkaloid content of the generative organs was estimated in three different ways.

Method a): After evaporating the methanol extract from the above-ground plant material the alkaloids were extracted with 2% H_2SO_4. The alkaloids were extracted from the acidic solution with chloroform in the presence of tropeoline 000 indicator. The alkaloid content was measured photometrically at 485 nm.

Method b): The quantity of alkaloids with an α-methylene-indoline moiety was roughly assessed by direct photometric measurement of the methanol extract at 328 nm.

Method c): The tabersonine content was determined from a petroleum ether extract of the plant material at 328 nm after preparative TLC separation performed on aluminium oxide $60F_{254}$ neutral sheets (Merck) in the presence of authentical tabersonine. The developing system was benzene. The tabersonine content was occasionally checked by other methods, too.

The phytomass of the above-ground shoots as well as that of their generative organs are demonstrated in Table 1. The means refer to the whole vegetation period. Mathematical statistical analysis of the data (with paired comparison) reveals differences only between the *Amsonia* species and *Rhazya orientalis*. Differences were also found in this context if the tendencies of variation during the vegetation period were taken into consideration. *Rhazya orientalis*, unlike the *Amsonia* species, showed little change in total shoot phytomass (Fig. 1) though both the proportion;of generative organs in the total shoot phytomass (Fig. 2) and the weight of the follicles (Fig. 3) increased. The variations in the above-mentioned parameters of *Amsonia* species, however, follow maximum curves. At the end of the observation period the *Amsonia* shoots were defoliated, desiccated and lost their seeds, while *Rhazya* was in the developing stage even in this period, at least regarding its generative organs.

Table 2 summarizes the mean alkaloid contents of the follicles over the whole vegetation period and of those from seeds gathered in October. In the first case the time-dependent variation could also be studied. The alkaloid content of all taxa showed a decreasing tendency with the development of the plants. These changes can be satisfactorily described by linear functions, which are well expressed by the correlation coefficients. With regard to the corresponding means in the table, no mathematically justified differences could be found.

As for the alkaloid production of the taxa, the annual means presented in the form of a column diagram (Fig. 4) showed certain mathematically significant differences between *Amsonia angustifolia* and the others. This should, however, be confirmed by other experiments.

Fairly close positive correlations were found between the weight of follicles and their tabersonine production (Fig. 5). This suggests that the highest tabersonine production can be expected in the most developed follicles.

On the basis of the experiments discussed here, a significant fluctuation in the alkaloid production was established, partly due to the stage of development and partly to the differences observable within the particular species. From this point of view, despite certain tendencies, none of the species studied can be excluded as potential sources of tabersonine.

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RECLAMATION OF SOLONETZ SOILS IN HUNGARY*

Solonetz and solod soils are wide-spread on each continent. They frequently occupy considerable areas but may also occur in spots on fertile land.

In solonetz soils, as is generally agreed, the high exchangeable sodium content is responsible for the compact B-horizon. In the A_1 and A_2-horizons of solod soils a very pale layer is formed, often with lower salt and exchangeable sodium contents, but its physical and water properties are also poor. These properties, hindering water movement and diminishing the water reserve available for plants, cause the low fertility of solonetz and solod soils (ANTIPOV-KARATAEV 1953, 'SIGMOND 1927).

It may be stated that the low fertility of solonetz and solod soils, caused by several factors, poses a complex problem in which the salt content and the salt balance of the soils play a decisive role (SZABOLCS 1965). This is why, when dealing with problems of both the genetics and the utilization of solonetz soils, one has to examine not only the exchangeable cation content of the soils, but their water soluble salt content, too (ANONYMOUS 1967).

Solonetz soils practically always contain a greater or lesser quantity of water soluble salts, mainly sodium salts (KOVDA 1946—1947). This salt content is not only a factor which decreases soil fertility by increasing the osmotic pressure of the soil solution, and sometimes by exerting a direct toxic effect, but also, by affecting the adsorption complex, it exercises a continuous influence on the composition of the exchangeable cations in the soil (SZABOLCS 1961).

In Hungary solonetz soils are fairly widespread and the total area of soils affected by salinization and/or alkalization is as high as 1271.6 hectares. This territory exceeds 10% of the total area of the country and represents about 15% of the land utilized for agriculture, silviculture and horticulture. Hungary belongs to those few countries in Europe where salt affected soils frequently occur and where the ratio between non-sslt affected soils and salt affected soils is very high. This fact, and the high density (about 80%) of the agricultural, silvicultural and horticultural utilization of the country, explain why Hungarian soil science has been closely related throughout its history to the problems of soil amelioration and particularly to the amelioration of solonetz soils, which prevail among all the kinds of salt affected soils in this country.

In Fig. 1 a schematical map of the distribution of salt affected soils in Hungary is presented. This map not only demonstrates the frequent occurrence of salt affected soils, but also the fact that the majority of these are to be found in lowland regions.

The reclamation of solonetz soils is necessary and possible on large areas, as well as for the improvement of smaller spots found between soils of good quality.

The reclamation of solonetz soils in Hungary was begun as early as the end of the 18th century by Sámuel Tessedik, who was the founder of agronomical sciences in this country. Tessedik — applying the rather primitive methods of his time — mixed the top-layer of these soils with sand and with soils of good quality. In the first part of the 19th century J. Irinyi discovered several chemical processes in the Hungarian salt affected soils and he was the first to recommend the application of $CaSO_4$ for the amelioration of solonetz soils.

Towards the end of the 19th century a new method was introduced for the reclamation of solonetz soils in Hungary: the application of compounds containing $CaCO_3$.

P. Treitz and S. Szentannai introduced this method into practice, and it is still in use in Hungary.

Between the two World Wars the government supported the reclamation of salt affected soils, and since the Second World War, parallel with the formation of large state and collective farms, the reclamation of soils has been carried out by the centralized governmental enterprises.

In comparison with the extension of soil reclamation during and after the Second World War the territory of improved soils increased in the fifties and particularly during the sixties of this century. This extension was considerable not only with respect to salt affected soils but to all types of improved soils (for instance acid soils, sandy soils, etc.).

* Lecture held at the XIIth Congress of the International Soil Science Society in New Delhi, India (8—16th February 1982).

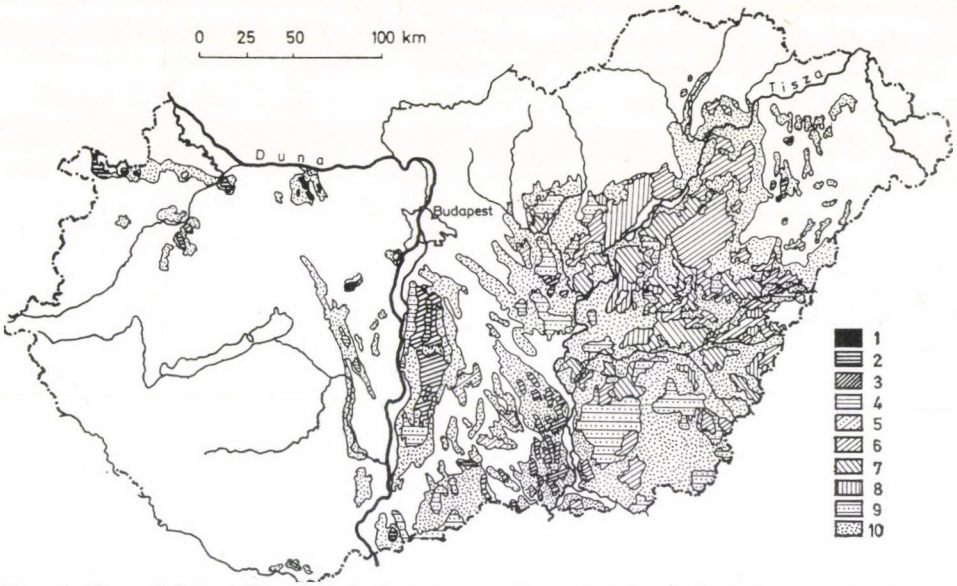

Fig. 1. Map of Salt Affected Soils in Hungary (compiled by I. Szabolcs—G. Várallyay—J. Mélyvölgyi, 1974. Original scale: 1 : 500 000). 1. Chloride sulphate solonchak; 2. Soda solonchak; 3. Soda solonchak-solonetz; 4. Calcareous meadow solonetz; 5. Calcareous solonetzlike meadow soil; 6. Meadow solonetz; 7. Meadow solonetz turning into steppe formation; 8. Solonetz-like meadow soil; 9. Soils salty in deeper horizons; 10. Potential salt affected soils

Figure 2 demonstrates the scale of soil amelioration in Hungary during the last forty years. The decrease which occurred in the seventies, following the increase in the sixties, can be explained by economic reasons, i.e. the reduction in governmental support.

Figure 2 shows not only the area of salt affected soils reclaimed, but also soil amelioration in general. It is clearly indicated in this figure that the overwhelming part of the ameliorated soils consisted of slightly acidic soils, which are followed by solonetz soils. Sandy soils,

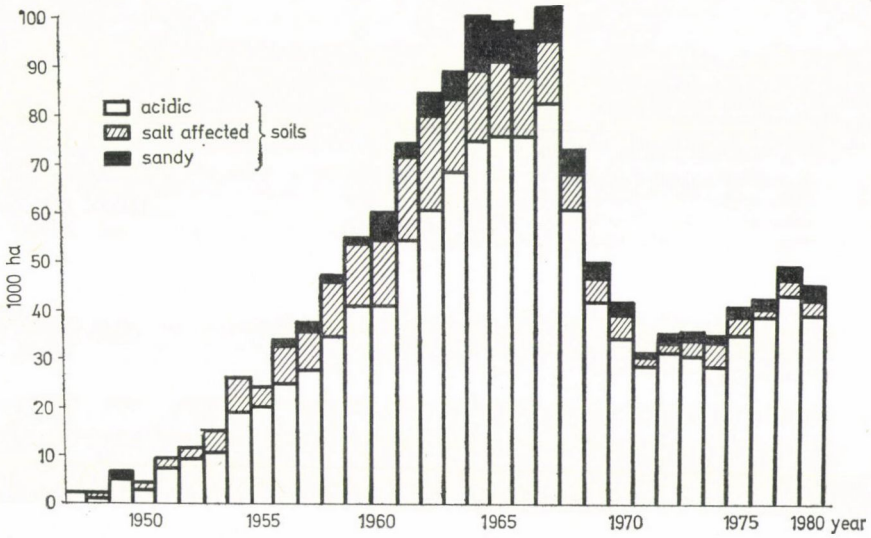

Fig. 2. Soil reclamation in Hungary

mainly blowsands, also occur in the country and these have also been ameliorated, as shown in Fig. 2.

In spite of the extended territories indicated in Fig. 2, a recent survey of Hungarian soils shows that the territory of solonetz soils waiting to be reclaimed has not diminished for a long time. This phenomenon can be explained by several reasons, for instance:

1. During new surveys new salt affected spots have been discovered.
2. The secondary formation of solonetz soils is fairly frequent on irrigated territories.
3. Intensive farming (high doses of mineral fertilizers) also contributes to the development of adverse soil processes.

It is fully agreed among soil scientists and agronomists in Hungary that the reclamation of solonetz soils will continue in the years to come. One condition for the success of this is a better knowledge of the properties and genetics of solonetz soils. This has already been taken into consideration to some extent during recent reclamations. However, if the rather expensive reclamation methods are to be efficient, accurate measurements of soil properties and exact calculations of both the quality and quantity of materials necessary for reclamations are imperative.

In Hungary and in the neighbouring countries the solonetz soils can be divided into three groups with respect to the possibility of reclamation, as shown in Table 1. In the table solod soils are also indicated in addition to solonetz soils. The properties and methods of reclamation for solod soils in this region are closely related to solonetz soils, which is why they should be grouped together.

1. In the case of solonetz and solod soils where the soil profile and the top layers are capillarily linked with salty ground water, and the horizons (A_1, A_2, B_1, B_2) contain large amounts of water soluble salts (more than 0.2% in the surface layer and 0.5% at a depth of 40—50 cm), the leaching out of salts and drainage are unavoidable. Chemical amendments should be applied either parallel to the above-mentioned measure or afterwards. Soils belonging to this group are genetically named meadow solonetz and solod soils.

2. If the profile of a solonetz or solod soil is only temporarily linked with ground water, and the salt content of the A, A_1 and B-horizons is lower than in the case of soils belonging to the first group, drainage is not always necessary. In these cases the application of chemical amendments (gypsum and/or others) as well as deep-ploughing and subsoil loosening may be useful. If in the B_2 and C-horizons the quantity of water soluble Na salts is not high and a considerable amount of gypsum is present, in the course of deep-ploughing it can be utilized as reclamation material. Soils belonging mainly to this group are called meadow solonetz and solod soils turning into steppe formation.

3. If the profile is not linked with ground water, its salt content (mainly in the top layers) should be taken into account when the suitable amelioration method is chosen. The climatic conditions, the possibility of irrigation, etc. are also decisive factors when the proper

Table 1

Schematic grouping of solonetz and solod soils with regard to their amelioration

Genetic type	Relation with ground water	Water soluble salt content in the surface layers	Amelioration*
1			
Solonchak-solonetz Meadow solonetz Meadow solod (shallow and middle)	permanently linked	more than 0.2% (about 4 mmhos)	drainage and chemical amendments
2			
Meadow solonetz and solod Soils turning into steppe formation	temporarily linked	about 0.2% (about 4 mmhos)	chemical amendments, deep ploughing and drainage if necessary
3			
Deep solonetz and solod soils Solonetz-like meadow soils	not linked	less than 0.2% (about 4 mmhos)	low amount of chemical amendments, proper agrotechnics and suitable crop (deep ploughing, alfalfa, etc.)

* The necessity of irrigation depends on local conditions.

methods are chosen to remove the salts and to improve the physical soil properties. Chemical amendments, deep-ploughing and subsoil loosening may be used as indicated in paragraph 2. Soils belonging to this group are called mainly steppe solonetz and solod soils, and solonetz-like meadow and other soils.

The three types of reclamation and utilization of solonetz and solod soils described above must always be carefully selected and adjusted to the local conditions. The chemical type of the salt content is very important and must be taken into account when the proper reclamation method is chosen. In the case of soda soils, for instance, the limit values of the admissible salt content in the soil profile are much lower than when the salinity is caused by neutral sodium salts.

As compared to neutral salt types, in the case of soda soils not only is a lower level of salinity required for successful amelioration, but in order to eliminate or at least lessen the detrimental effect of sodium carbonate, the application of acid chemical amendments — as one factor of reclamation — is practically always necessary.

Conclusions

In Hungary the reclamation of solonetz soils has a long tradition stretching back over nearly 200 years. In spite of reclamation, particularly in the period after the Second World War, the quantity of soils to be reclaimed has not diminished. This phenomenon can be explained partly by the discovery of new salt affected spots and partly by secondary processes of solonetz formation due to expanding irrigation.

In future reclamation, three types of solonetz and solonchak soils should be distinguished with regard to amelioration, as indicated in Table 1.

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SOME NEW NUCLEAR METHODS AND THEIR APPLICATIONS IN AGRICULTURAL RESEARCH AND PRACTICE*

1. Introduction

There are many applications of nuclear methods and procedures, and of radioactive isotopes in agriculture and related fields in Hungary. For instance, a fast method for protein determination by charged particle nuclear reactions was developed at the Central Research

* Invited paper at the 11th Annual ESNA Meeting, Debrecen, August 25—30th, 1980.

Institute for Physics (VARGA 1977); maize, soya, etc. seeds were irradiated for simulation by electrons and neutrons at the Nuclear Research Institute of the Hungarian Academy of Sciences in Debrecen (BORNEMISZA-PAUSPERTL *et al.* 1980). Furthermore, a symposium was recently organized in Budapest on the application of nuclear irradiation techniques in agriculture and the food industry (ANONYMOUS 1979). It would be quite impossible to enumerate completely all these applications.

Similarly, there are a number of new methods of nuclear origin which are or could be important from the point of view of agricultural science and practice. It would also be difficult to give a complete survey of all these methods, or even to mention them briefly.

Consequently, three methods are selected here which — although certainly familiar to experts in agriculture and related fields — are very promosing for this kind of application, and in connection with which the possibilities have not yet been exhausted. At the same time,

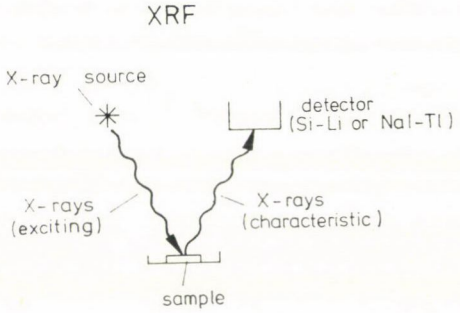

Fig. 1. Essentials of an energy-dispersive X-ray fluorescence analysis

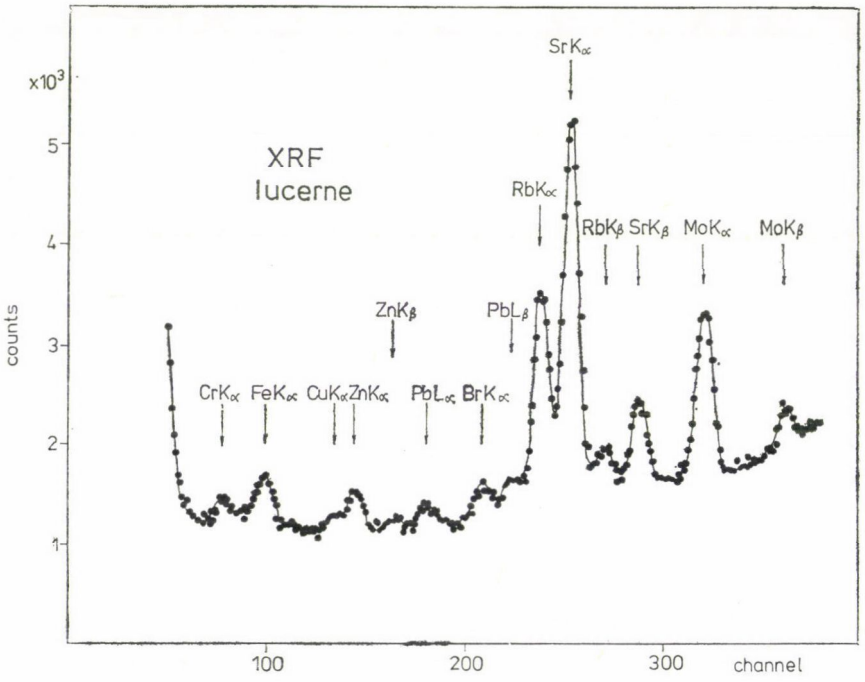

Fig. 2. X-ray fluorescence spectrum of a lucerne ash sample (KIS-VARGA 1975)

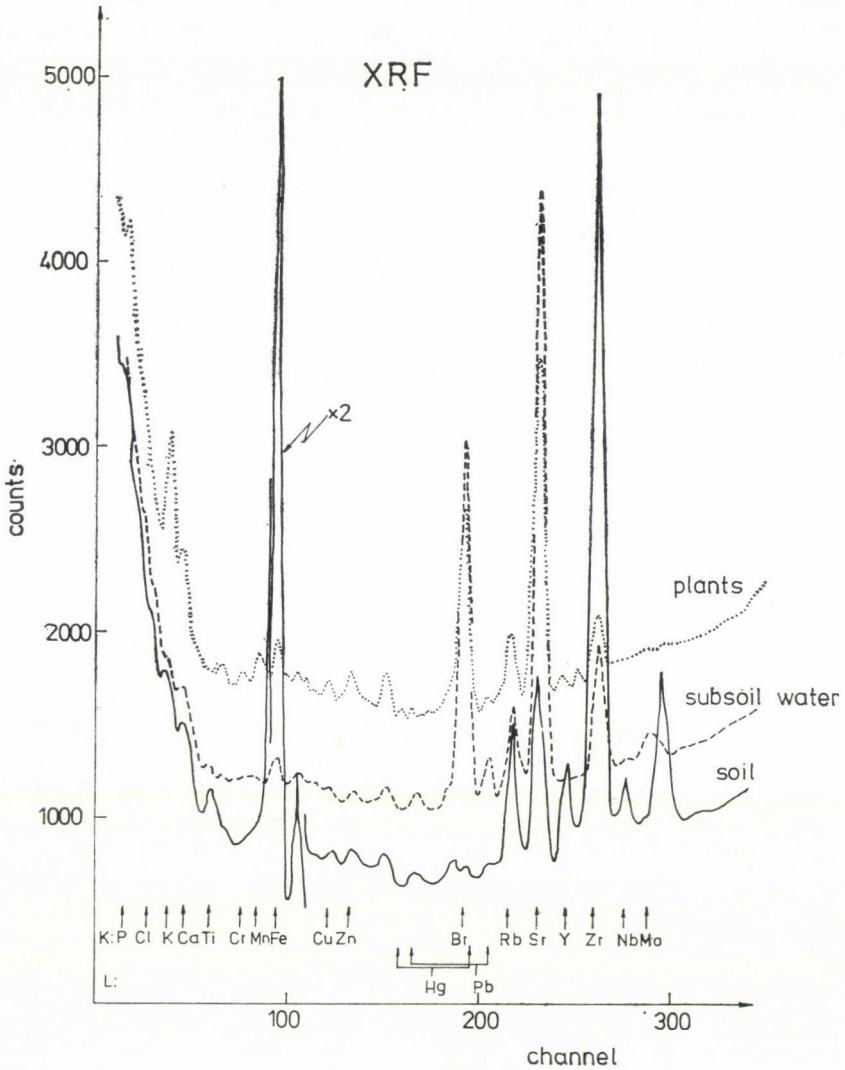

Fig. 3. A multielemental XRF analysis of soil, subsoil water and plants, respectively (BACSÓ *et al.* 1974)

experience has been gained with these methods in Hungary, so the choice seems quite justified. The three methods in question are XRF (X-Ray Fluorescence analysis), PIXE (Particle Induced X-Ray Emission analysis) and ESCA-XPS (Electron Spectroscopy for Chemical Analysis — X-Ray Photoelectron Spectroscopy).

2. X-ray fluorescence analysis (XRF)

The principle of the method is fairly simple (Fig. 1). When irradiated by X-rays from a radioactive preparation (or X-ray tube) the atoms of the sample emit characteristic X-rays. Thus, by detecting, recording and analysing the X-ray spectrum, a qualitative and quantitative analysis of the sample can be performed. As a matter of fact, the method is not really

new, but the appearance and constant improvement of semiconductor X-ray detectors has made this kind of analysis more and more versatile and efficient. (X-ray spectrometers with semiconductor detectors are called energy-dispersive systems, in contrast with the so-called angle-dispersive or simply dispersive systems with diffracting crystals.)

The main advantage of this method is the rapid, non-destructive, multielemental analysis down to a concentration value of 100—1 ppm for elements $Z > 11$, i.e. Na. (Basic information on the method is given by CARR-BRION—PAYNE 1970 and KNEIP—LAURER 1972.)

The above features are very valuable for the solution of many problems in agriculture and related fields. Two concrete examples of these applications will be mentioned in some detail. Both were carried out at the Nuclear Research Institute (ATOMKI), Debrecen, where experience has been gained for more than a decade in constructing and applying semiconductor X-ray spectrometers.

One of these studies is the investigation of a large number of lucerne samples for traces of metals, particularly molybdenum (KIS—VARGA 1975). Peaks corresponding to Cr, Fe, Cu, Zn, Pb, Br, Rb, Sr and Mo can be identified in the X-ray fluorescence spectrum (Fig. 2). A ^{125}I radioactive preparation was used here as the exciting source. From the analysis of these spectra, for example, the Mo concentration was determined to be in the region of 10 ppm in order of magnitude related to the dry plant material.

Another detailed study was carried out using the same method for multielemental analysis of the soil, subsoil water and plants from the same site (BACSÓ *et al.* 1974). The exciting source here was again ^{125}I. The corresponding spectrum is shown in Fig. 3 and the results are summarized in Fig. 4.

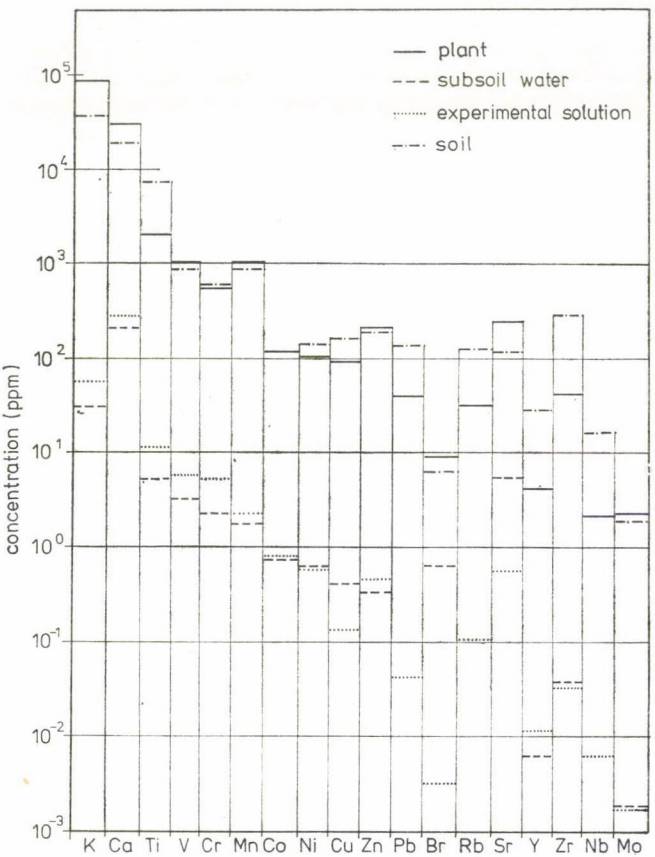

Fig. 4. Results of an experiment on the multielemental analysis of soil, subsoil water and plants by XRF (BACSÓ *et al.* 1974)

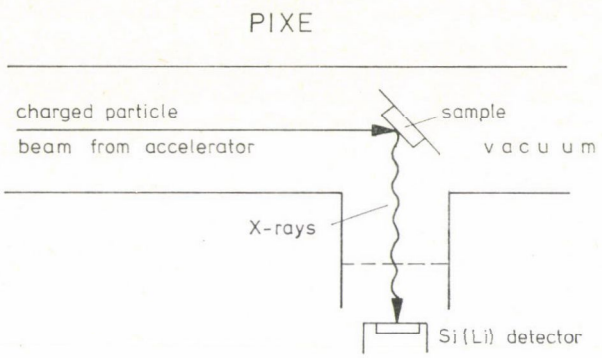

Fig. 5. Schematic diagram of X-ray emission analysis induced by charged particles (PIXE) (mainly protons or, alpha particles)

These are not all the results obtained in the field of agriculture by using this technique at the Nuclear Research Institute, still less do they exhaust all the possibilities of application, but I hope they will serve to illustrate satisfactorily the capabilities of the methods in general and at the Debrecen Institute.

3. Particle induced X-ray emission analysis (PIXE)

This method is fairly similar to the previous one; it can be regarded as a further development of XRF. Here, however, the sample is irradiated by an ion beam (mainly protons or alpha particles) from a nuclear accelerator (Van de Graaff, cyclotron) and the characteristic X-rays emitted from the specimen are detected by a Si(Li) X-ray energy dispersive spectrometer (see the outline of the arrangement in Fig. 5). This latter part of the system, with the connected electronic units, is practically the same as for XRF, so an X-ray spectrum must be analysed in order to obtain analytic information. PIXE also has the same limitations concerning the elements which can be analysed ($Z > 11$).

This method, in comparison with the earlier XRF, is more suitable for trace analysis, since it has a much higher sensitivity (i.e. the smallest mass of a given element which can be determined), sometimes orders of magnitude higher (i.e. the detectable mass is smaller).

A doubtless disadvantage of PIXE is the need for a nuclear accelerator to carry out such an analysis. The other disadvantage, that the samples must be introduced into the vacuum space of the accelerator, can sometimes be eliminated by bringing the charged particle beam out of the vacuum through a suitable window. However, it is an important feature of PIXE

Table 1

Trace element concentration in tomato juice

(Ishii *et al.* 1975)

	ppm
Fe	2.5 ± 0.4
Cu	0.85 ± 0.13
Zn	0.90 ± 0.14
Cd	13 ± 5
Sn	57 ± 13
Pb	1.7 ± 0.4

that specimens of very small quantities can be analysed (a few μg), but thick samples can be studied, too. Further details on PIXE are given by DECONNINCK *et al.* (1975), JOHANSSON—JOHANSSON (1976) and MITTLER *et al.* (1977).

The value of PIXE is quite evident from the present point of view. In fact, the utilization of this technique has been started worldwide and only some typical examples will be mentioned here. Trace elements have been studied in water (LOCHMÜLLER—GALBRAITH 1974) and in tomato juice (ISHII *et al.* 1975). In biological tissue materials the concentrations of K, Ca, Ti, Mn, Fe, Co, Ni, Cu, Zn, Se, Br, Rb, Sr, Cd, Cs and Pb have been determined (MANGELSON *et al.* 1979). In Table 1 the trace elements found in tomato juice are given (ISHII *et al.* 1975).

PIXE measurements were started at the Nuclear Research Institute several years ago (VÉGH *et al.* 1978) and various measurements using PIXE are currently in progress. For example, in Fig. 6 a PIXE spectrum of human blood is shown which was taken at the Institute (GÖDÉNY *et al.* 1979).

It is quite understandable that the method concerned is of high importance in research on environmental pollution. Such investigations are conducted here in collaboration with the Central Institute for Atmospheric Physics (LÁSZLÓ *et al.* 1980). Fig. 7 shows the spectrum of an aerosol sample.

It is our conviction, however, that this method is not fully utilized as yet.

4. Applied electron spectroscopy (ESCA-XPS)

The acronym of the method is not used uniformly. The terms ESCA (Electron Spectroscopy for Chemical Analysis) and XPS (X-Ray Photoelectron Spectroscopy) are used alternately in general to designate the same method. One of the most important bases on which this technique has developed is the beta-ray spectroscopy of radioactive materials, even though no radioactive source is necessary now for a study performed with ESCA.

In such an analysis the sample is irradiated by X-rays and the spectrum of the photoelectrons produced by the X-rays is measured by an electrostatic electron spectrometer. The most important parts of the relevant equipment are indicated schematically in Fig. 8.

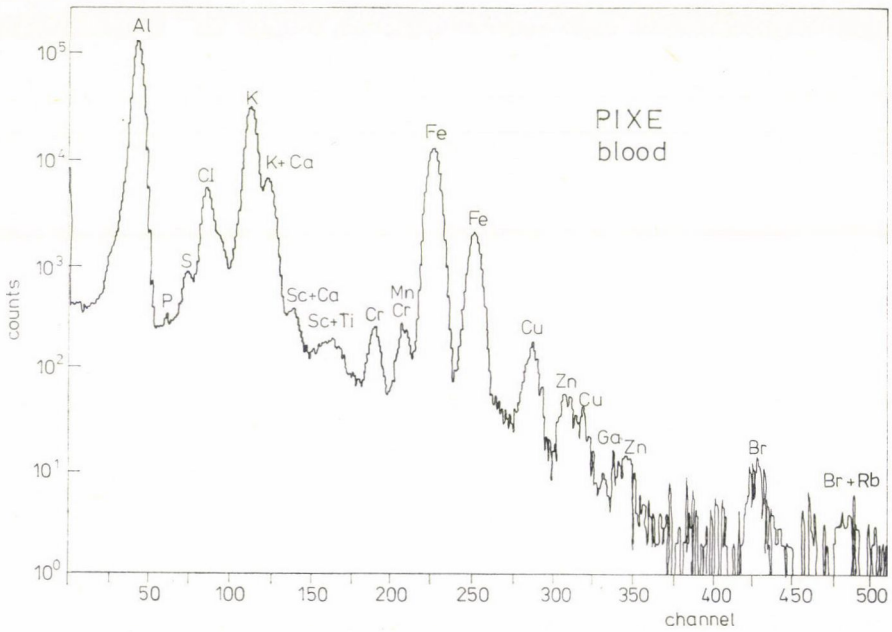

Fig. 6. Spectrum of X-rays from a blood sample of a gravid woman. The sample was irradiated by 2 MeV protons in the 5 MV Van de Graaff at the Nuclear Research Institute, Debrecen (GÖDÉNY *et al.* 1979)

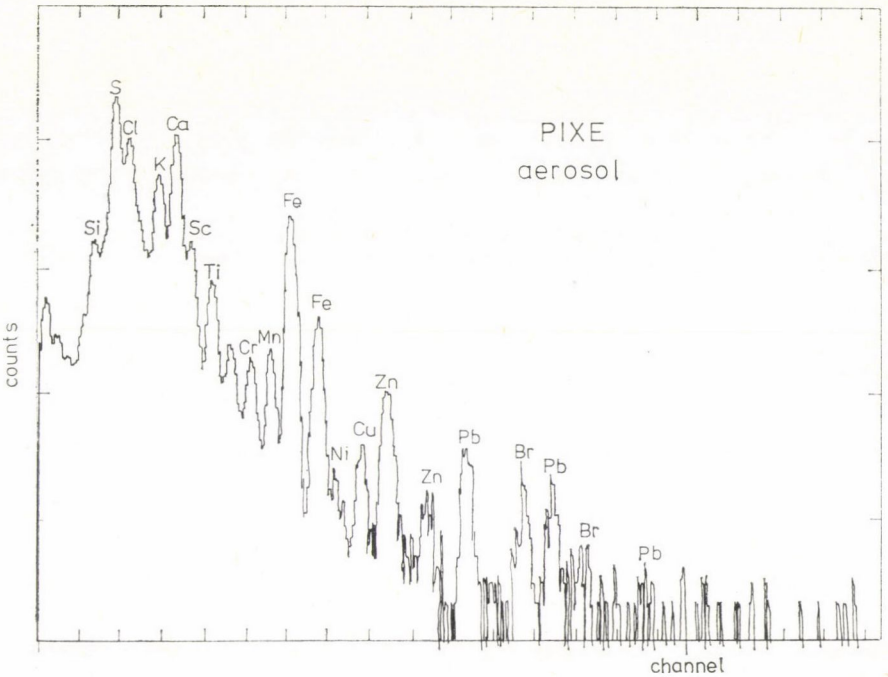

Fig. 7. Proton (2 MeV) induced X-ray spectrum of an aerosol sample (250 $\mu g/cm^2$ layer on the surface of a filter through which 0.48 m^3/cm^2 air passed) (LÁSZLÓ *et al.* 1980)

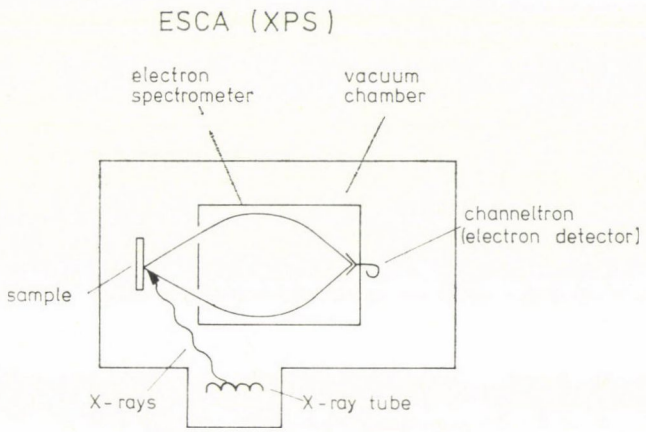

Fig. 8. Simplified scheme of equipment for ESCA studies. Neither the necessary electronic units, power supplies, multichannel analyser or computer, etc., nor the vacuum system are indicated

What are the most important properties of ESCA from the point of view of our present interest? The method is able to give information about the valence state or, more generally, the molecular environment of the atom in the sample. Thus, for example it can differentiate between sulphur in the 4+ or 6+ valence state, i.e. whether the S atom in question is in a sodium sulphite or in a sodium sulphate molecule. ESCA is especially suitable for the study

of the various monolayers on the surface of a sample (but not exclusively for this) and it is sensitive for all the elements except H, including such important light bioelements as C, N, O, etc. At the same time the sensitivity is very high, in absolute figures 10^{-8}—10^{-10} g. Not only reviews (BERÉNYI 1974, 1976) but also good books are now available on the details of applied electron spectroscopy (BAKER—BETTERIDGE 1972, BRUNDLE—BAKER 1977—79 and others). It should be mentioned here, however, that there are also several other types of applied electron spectroscopy besides ESCA-XPS, e.g. those in which the photoelectrons are produced by ultraviolet irradiation (UPS), etc.

Although the application of the method to problems related to agricultural research and practice has only just begun, results published so far seem to be quite promising. An espe-

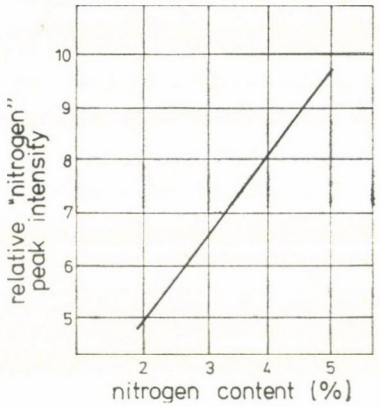

Fig. 9. The connection between the nitrogen content of various plant samples (representing the protein quantity in them determined by micro-Kjeldahl analysis) and the relative intensity of the peak corresponding to nitrogen in the ESCA (X-ray excited photoelectron) spectrum on the basis of a study by PEELING *et al.* (1976)

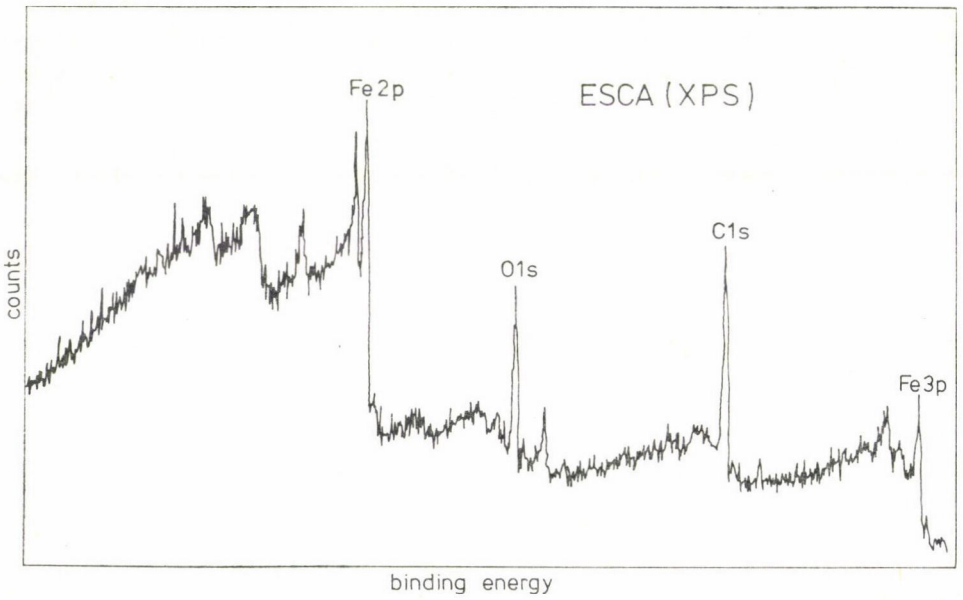

Fig. 10. X-ray excited photoelecton spectrum of a sample where the peaks corresponding to the important bioelements (O and C) are well visible (KÁDÁR *et al.* 1980)

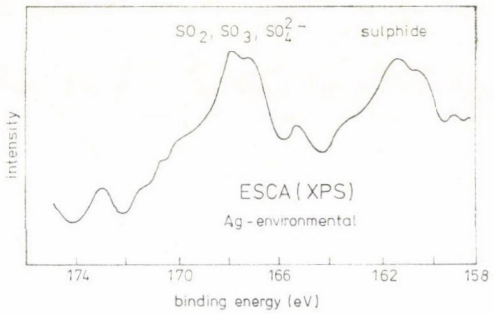

Fig. 11. Part of an X-ray excited photoelectron spectrum in the region of the peaks corresponding to sulphur. The sample was an Ag plate placed in the neighbourhood of a busy road for a week (KÖVÉR 1980)

cially interesting series of studies was carried out for proteins: the total protein content of various species of grain was determined by measuring the sulphur and nitrogen peak intensities in the photoelectron spectra (KLEIN—KRAMER 1970). With this method the protein quality can also be assessed (PEELING *et al.* 1976), since a higher sulphur content means higher quality. Figure 9 shows schematically the linear connection between the nitrogen content (representing the protein quantity) of various samples determined by the wet chemical method and the relative intensity of the peak in the photoelectron spectrum corresponding to nitrogen according to the study of PEELING *et al.* (1976).

The method is valuable in environmental studies as well (HERCULES—HERCULES 1972). For example, the chemical states of N and S were studied in aerosol samples as a function of particle size and time of day (NOVAKOV *et al.* 1972).

A technique of electron spectroscopy suitable for the above applications has been developed in the Nuclear Research Institute, Debrecen, over the last 8—10 years. Altogether six electron spectrometers were constructed or are now under construction and were applied for the study of various problems (KÖVÉR *et al.* 1978, KÖVÉR 1978, VARGA *et al.* 1978). To demonstrate the virtue of ESCA in the field of the present conference, two examples from the current investigations are given. In Fig. 10 a spectrum is shown where the peaks correspond to the important bioelements: carbon and oxygen are visible (KÁDÁR *et al.* 1980). The spectrum in Fig. 11 shows the structure of the peak corresponding to sulphur in the case of an environmental sample. A silver plate was put out in the neighbourhood of a busy road for a week. In the spectrum the appearance of peaks for SO_2, SO_3 and SO_4^{2-} can be seen, originating from the air. They are practically missing in the case of the control plates.

The above examples should demonstrate the capabilities of this method.

5. Closing remarks

Besides the techniques, procedures and results presented in this paper, there are a number of others in use at the Nuclear Research Institute, and elsewhere in Hungary and especially worldwide, which are or could be important from the point of view of the subject of the present conference. Many of these will be discussed in detail in the working groups. It is hoped, however, that the demonstration of three modern methods in some detail will not be lacking in value from the view-point of the successful work of this conference.

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RECENSIONES

SCHULZ-SCHAEFFER, J.: *Cytogenetics; Plants, Animals, Humans.* Springer-Verlag, New York—Heidelberg—Berlin, 1980, VI + 446 p.

Cytogenetics is a science on the border between cytology and genetics. According to an earlier definition it is a field of genetics dealing with the structure, division and relations of the chromosomes. However, according to recent investigations, DNA, the carrier of inheritance, is a component not only of the chromosomes but also of certain plasma elements; thus, with the widening of our knowledge, the scope of subjects studied by cytogenetics has been extended. It is no longer easy to decide which of these fields of science belongs to physiology, which to biochemistry, cytology or genetics, which of them to two or more branches of science, and which forms the subject of cytogenetics.

For the last twenty years the author has held cytogenetic courses at Montana State University for students from seven faculties, and when compiling the material for this book he took this wide range of demands into consideration. Consequently the book covers a large scope of science and it is impossible to give a satisfactory review of it without supplying brief information about the contents.

After a short preface the book is divided into nine sections made up of 20 chapters (345 pages), general and specific references (69 pages) and an index (27 pages).

Part I. Introduction; 27 pages. Chapter 1. History of Cytogenetics. As stated by the author, this encompasses the major events of cytogenetics between 1591 and 1974, from the microscope-makers Sachariassen and Janssen to a wider knowledge of palindrosomes.

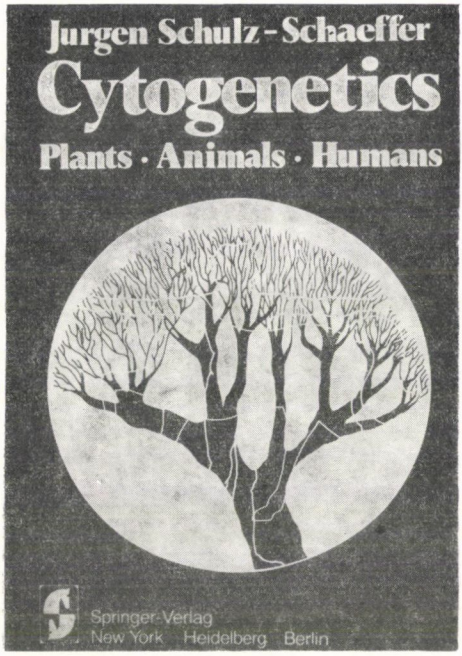
Part II. Structure of Chromosomes; 28 pages. Chapter 2. Gross Morphology of Chromosomes. Morphology of mitotic and meiotic chromosomes. Chapter 3. Fine Structure of Chromosomes. Structures of DNA and RNA, nucleoproteins, chromosome ultrastructures.

Part III. Function of Chromosomes; 26 pages. Chapter 4. Function of Autosomes. Coupling, mechanism of crossing over (theory of partial chiasmatype, Belling and the hypothesis of copy-choice, polaron hybrid DNA model and its cytological basis, gene mapping). Chapter 5. Function of Sex Chromosomes. The X—Y system (the theories of Bridges, Goldschmidt and Pipkin), role of Y chromosome, dosage compensation (Lyon hypothesis, euchromatin, facultative and constitutive heterochromatin, satellite DNA, redundance, drumsticks), sex-bound characters.

Part IV. Movement of Chromosomes; 11 pages. Chapter 6. Chromosomes during Mitosis. M, G_1, S and G_2 phases; mitotic division. Chapter 7. Chromosomes during Meiosis. Description of the different phases of reducing division, which ensures the maintenance of chromosome number on fertilization, the processes taking place in them and various irregularities, illustrated with micrographs. Chapter 8. Chromosomes during Sexual Reproduction. Microsporogenesis and spermatogenesis, megasporogenesis and double fertilization in plants; spermatogenesis, oogenesis and syngamy in animals.

Part V. Variation in Chromosome Types; 26 pages. Chapter 9. Polyteny and Lampbrush Chromosomes. Comparison of polyteny and endopolyploidy, characterization of polytene chromosomes, puffs, super and lampbrush chromosomes. Chapter 10. Ring-Chromosomes, Telocentric Chromosomes, Isochromosomes and B Chromosomes. Origin, morphology and occurrence of the above listed chromosome types.

Part VI. Variation in Chromosome Structures; 66 pages. The most detailed part of the book. Chapter 11. Chromosome Deletions. Breakage-reunion and exchange hypotheses of their origin, spontaneous and induced aberrations (the autosomal, recessive, hereditary Falconi's anaemia in humans, Bloom's syndrome and the Louis-Bar syndrome are mentioned here), terminal deficiencies and interstitial deletions, the breakage-fusion-



bridge cycle (dicentric chromosomes, deletions and duplications), detection of deletions, human deletion syndromes (a clinical syndrome related with chromosome deletion in humans was first identified in 1963 and others have since been found). Chapter 12. Chromosome Duplications. Types and origin of chromosome duplications, position effect, the activator-dissociation system and other phenotypic effects, human chromosome duplication syndromes. Chapter 13. Chromosome Inversions. Occurrence and manifestation of pericentric, paracentric and complex inversions, crossover suppressory effect of inversions. Chapter 14. Chromosome Translocations. Types and origin of translocations, translocations in humans, complex heterozygoty — Oenothera and other systems, chromosome mapping through translocations by the use of tester series.

Part VII. Variation in Chromosome Number; 67 pages. Chapter 15. Haploidy, Diploidy and Polyploidy. Origin of haploids (spontaneous and induced haploids), meiotic behaviour and utilizability of mono- and polyhaploids, diploidization; classification of polyploids (auto-, segmental allo- and genome-autoallopolyploids), their characterization, occurrence, artificial induction and use in plant breeding; complications in humans and animals. Chapter 16. Aneuploidy. (In the case of euploidy the cells contain the basic chromosome number of the genus or its multiple, while with aneuploidy the number of chromosomes is different.) Occurrence, utilization and classification of aneuploids: nullisomy (demonstrated by the example of spike shape in the nullisome series of the wheat Chinese Spring), monosomy, telosomy, various types of trisomy and its pathological effects in humans, tetrasomy.

Part VIII. Variation in Chromosome Function and Movement; 33 pages. Chapter 17. Variation in Function of Autosomes. Somatic segregation (somatic crossing-over, chromosomal chimera and mosaics), variations in mitosis and meiosis (asynapsis and desynapsis; deviations in size of chromosomes, spindle formation and in the course of division), genic male sterility. Chapter 18. Variation in Function of Sex Chromosomes. Sex ratio and sex chromosome systems. Chapter 19. Apomixis and Parthenogenesis. Reproduction of plants without pollination and of animals without insemination, including illustrations on some 9 pages.

Part IX. Extrachromosomal Inheritance; 15 pages. Chapter 20. Plastids, Mitochondria, Intracellular Symbionts and Plasmids. The intracellular symbionts include the P-particle of Paramecium, the maternal sex ratio and *Sigma* virus of *Drosophila*, the mouse milk factor and the cytoplasmic male sterility of plants, while the following sections of the chapter discuss phenomena discovered in studying the genetics of bacteria and phags, under the title Plasmids, Episomes and Transposable elements.

This well-produced book contains a vast amount of material, including figures and micrographs, many of which are original. The various processes are described imaginatively, and a wide range of literature is cited. It will chiefly be of use in university education, but can be recommended to anyone interested in cytogenetics and possessing an adequate basic knowledge of genetics and cytology.

Of course, even this work cannot be said to be perfect, if only because of the vast material covered, and the variety of subjects discussed. A maize breeder, for example, may find the section on the cytoplasmic male sterility of maize to be too short and would not be interested in the cytogenetics of Sciaria, while the physician is not interested in the cytoplasmic male sterility of maize. The author was obviously aware of this fact himself, as references are given to comprehensive works providing wider knowledge to those interested in the various subjects. In addition, a brief explanation of the special cytogenetic terms used in the text would make it easier to acquire a thorough knowledge of the subject.

It is a pity that here and there the book shows signs of carelessness. Some authors,

e.g. Amici, Guignard and Navashin Sen. among the older generation, Chargraff and Khorona among the authors of recent works, are not included in the list of references. This is, naturally, a personal matter; the author probably did not consider it necessary to emphasize the priority in every case. There are a few other mistakes too. The F_1 male in Fig. 5.7 (page 87) is red-eyed and not white-eyed as indicated in the text. In Fig. 16.8 A—D (page 281) the letter A is missing, while Fig. 13.1 (page 204) is meaningless, since the letters marking homozygote and heterozygote inversions are incorrect.

L. DANIEL

L. NÉMETI: Magyarország élelmiszer-gazdasága a hetvenes években *(Food economy of Hungary in the seventies)*. Mezőgazdasági Kiadó, Budapest, 1981, 216 pages, 75 tables, 14 figures.

Ever since food economy was adopted by the profession not only as a concept but as a technical term too, its evaluation has been chosen as the subject of a number of studies. One of the prominent authors is Dr. László Németi, who interprets the development of food economy in the last decade on the basis of statistical data.

It is self-evident that it is almost impossible to pick out such a relatively short phase in the development of any branch of the national economy without mentioning the precedents. For this reason the author is justified in referring (briefly, but aptly) to the circumstances which made this upward trend, unparallelled in the economic history of Hungary, possible. The most important of the causes (and this should perhaps have been given more emphasis) is the agricultural policy that brought about a coordination of productive forces, production conditions, economic and social circumstances, and consequently made it possible for food economy to evolve.

Chapter 1 informs the reader that in the period concerned the value of food production in Hungary rose by around 48% (per hectare of agricultural area) compared to the world average increase of around 20%. The picture becomes still more favourable if the per capita production value is taken into consideration, since the 40% increase in domestic production by far exceeded the world average of only 5%. And if the increment per agricultural worker is calculated, the ratio will be 17 to 83% "in Hungary's favour". (Nor should it be forgotten that in most foreign countries the concept of agricultural worker is much more narrowly defined than in Hungary.)

László Németi attempts a really formidable task when examining the share of agricultural products within the total production of the national economy as well as the relative indices of gross and net production. He is undoubtedly right in saying that it is principally the price policy that shapes and thus modifies these ratios, and in the case of food economy also distorts them. Apart from this, it is often difficult to obtain a clear picture because the economic regulators encourage the development of one or another sector by means of rather indirect support. So the output and cost data are somewhat difficult to separate from the various subsidiary contributions.

The change in the production structure gives a clear indication of the fact that the cultivation of crops such as wheat and maize, for instance, where mechanization and chemization are easy to introduce, was the first to be modernized, at a rate almost equal to the yield increase. Since, however, the costs of mechanization and chemization also rose continuously during the period in question, in spite of the large number of restrictions, greater emphasis was laid on regional production, which meant that the location of crops was often decided, quite rightly, according to the ecological conditions.

In the livestock sector changes in the number of animals followed the economic regulators with the same closeness. During this period the cattle programme yielded the expected results: the increase in milk pro-

duction was particularly noteworthy: in 1980 the total milk production was 51% higher than ten years earlier. The production on household plots and subsidiary farms also rose, in particular during the second half of the seventies.

As regards the food industry, there were still problems caused by the original lack of development (especially with respect to buildings and machinery). The development of the preserves, sugar and vegetable oil industries by far exceeded that of the milling industry. The author points out that the resolution passed by the Central Committee of the Hungarian Socialist Workers' Party in October 1977 undoubtedly accelerated the transformation of the production structure.

In Chapter 2 László Németi analyses the trend in food turnover. He gives a competent description of the relationship between income and food consumption, and rightly attaches special importance to the fact that the general increase in incomes helped to establish more sensible dietary habits. Nevertheless, the remarkable differences in the purchases of meat, milk, dairy products, vegetables and fruit between different households cannot be ignored. However, as far as national averages are concerned, very considerable positive changes have taken place from a nutrition and health point of view.

Meat consumption has risen from 60 to 72 kg, milk and dairy product consumption from 111 to 161 kg, and egg consumption from 14 to 19 kg. At the same time, the proportion of flour and potatoes in nutrition has become somewhat lower, while the amount of fats has shown hardly any decrease.

It is quite obvious that a further increase would be desirable in the share of milk, dairy products, vegetables and fruit in the diet, the conditions for which have already been provided by the food economy. Furthermore, the present 20—22% vegetable fat within the approx. 31 kg/capita annual fat consumption should be increased (the European average is 40—50%).

The market demand for coffee and tobacco, and particularly the data on alcohol consumption, are rather though-provoking. Parallel to a slow decrease in wine consumption (from 39 to 35 l), the consumption of spirits showed a by no means welcome increase from 6 to 10 litres.

The author rightly points out certain (not easily explainable) contradictions in the price structure, which have had an adverse effect on the development of desirable nutrition habits. For example, while the prices of "shop" foods rose by 12%, those of vegetables and fruits rose by 50—70% between 1970 and 1976.

On the other hand, it is very encouraging to see that agricultural and food exports showed a dynamic increase in the period under survey.

This can be characterized by the fact that in 1980 the rouble value of exports exceeded the 1970 level by 92%, and the dollar value by 179%. Thus, food economy made a really handsome contribution to the balance of payments.

Unfortunately, it is generally extremely difficult to determine the economic efficiency of exports, particularly as the constant fluctuation of world market prices and the various protectionist and discriminative measures carried by western countries frustrate apparently realistic calculations based on output-input conditions. Thus, the only way seems to be that chosen by László Németi, who attempts to establish reliably exact economic efficiency indices for the exports of a particular product in a particular year.

It is a moot point, for instance, whether the more highly processed products are really a more economical export commodity than primary products or raw materials. The very contradictory supply-demand conditions on the world market sometimes disprove this surmose, and not only in the case of beef production (mentioned by the author).

Chapter 3 analyses the situation of production forces. It throws light upon the regrettable fact that, as in many other countries, Hungarian agriculture is not free from the danger of reductions in the cultivation area. In the period under examination the total agricultural area was reduced by 250 thousand ha, and what is more, the arable area was reduced by about 300 thousand ha.

The author would have done well to lay greater emphasis on this fact, rather than maintaining his role of objective informant, since it must be stressed that according to our present knowledge the soil is an irreplaceable resource, a national treasure which must be cared for, maintained and rationally used at all costs. The quantity of good quality soil is undoubtedly decreasing all over the world. In some places a certain proportion of it is taken away by the infrastructure, in other places it is turning into desert or being destroyed by chemical deterioration or stagnation of the soil life, accompanied by erosion.

This is one reason why László Németi's fully warranted calculation that the total area of inferior soils in Hungary is about 5 million ha should definitely be underlined. If only 1% of this area is ameliorated each year, as has recently been the case, further irrecoverable losses must necessarily be reckoned with.

Amelioration is closely related with irrigation. The data indicate that the size of the

irrigated area is much smaller than either desirable or possible. The causes of this deficiency are correctly pointed out by the author. His remarks could be usefully complemented by the fact that the more up-to-date, water-saving methods of irrigation deserve much greater attention.

A clear picture is given of the situation of fixed and current assets in all sectors. The labour situation is discussed by the author at length, as required by the importance of the question. The proportion of active agricultural workers (within the total number of employed) was reduced by a further 4.5% (some 200,000 persons) in the period in question.

This reduction in numbers was partly counterbalanced by the rejuvenation of the labour force, since many young workers entered agriculture, and by the increase in the professional standard. The proportion of skilled workers and graduates increased. It should be noted, however (and here the author is again justified in making a comparison), that the proportion of physical workers in the non-agricultural sectors is 65.3% as opposed to 82.6% in agriculture. And this only partly follows from the nature of agricultural work. It should also be mentioned that the distribution of graduates among the farms is not as favourable as we should like it to be either.

Chapter 4 deals with the efficiency of production. Here the author is inevitably faced with the problem of how to interpret the term efficiency, and he is justified in analysing the output-input ratio. However, the determinative influence of prices must, unfortunately, also be taken into account, and the actual ratios are, therefore, modified to some extent. The author makes the relevant comparison that the price of a sugar-beet combine corresponds to the annual average income of 80 agricultural workers in Hungary and of 10 in the Federal Republic of Germany. In this case it is obvious that in Hungary (relatively) cheap manual labour is replaced by a (relatively) expensive machine. Thus, although technological development may improve the productivity of live labour, it nevertheless lessens the efficiency.

It is quite natural that the quality of the soil, even at the present technological level, influences not only the yield, but also the efficiency of production. As a consequence of technological development specific yields have undoubtedly increased, i.e. fertility per unit area has improved.

The author uses the term "productivity per unit area" both in the sub-title and in the text. I do not agree with this, since Hungarian economic terminology applies the term "productivity" to live labour. Productivity is thus regarded as an index expressing either the number of working hours required for the production of one unit of product, or the number of products produced in a unit of time.

At the same time, fertility in this sense means the productive capacity of the plant as brought about by the soil, i.e. it is a biological-agronomical property associated with the soil.

Subsequently, the author himself examines productivity as defined by this economic concept. According to the data which are perhaps the most characteristic of this (Table 53), the productivity of maize growing, for example, increased 3.9-fold (6.26 : 1.61) in the period under survey. (This is the joint result of an increase in the yield level, on the one hand, and a reduction in the number of working hours required for the production of 100 kg yield, on the other.) In order to give a clearer picture, this undoubtedly favourable change should perhaps have been compared with the change in efficiency for the same item in the same period, since the efficiency, i.e. the index indicating the ratio of the joint value of live and dead labour required for the production of 100 kg maize, showed a change in the opposite direction, due primarily to the increased prices of implements and materials.

Calculations concerning the efficiency of fixed assets do not always reflect this contrast with sufficient intensity. There can be no doubt that László Németi is right when he says that the possibility of an improvement in assets efficiency can only be created by the coordination of the biological, ecological, chemical, technical and, above all, human factors of production.

In Chapter 5 (The regulatory system of food production) the author expresses quite a number of his own ideas when evaluating the conclusions drawn from the data presented. He approaches a particularly difficult problem when discussing the differentiation of farm production. He is undoubtedly right in stating that even if production is less efficient under domestic price conditions, it may still be profitable from a world market point of view. This obviously demonstrates the still uneliminated deficiencies of the regulatory system, or elements of the system which, while necessary for the national economy as a whole, have, as noted by the author, an adverse effect on food production.

After Chapter 6, which gives a concise but informative account of organizational forms, the reader turns expectantly to the last chapter, Chapter 7, that is designed to draw conclusions, and is not disappointed. László Németi does not lose his way in the mass of data, and finally points unerringly to the

crux of the matter. He constantly advocates the consistent application of a task-wage system as one of the main stimuli of development.

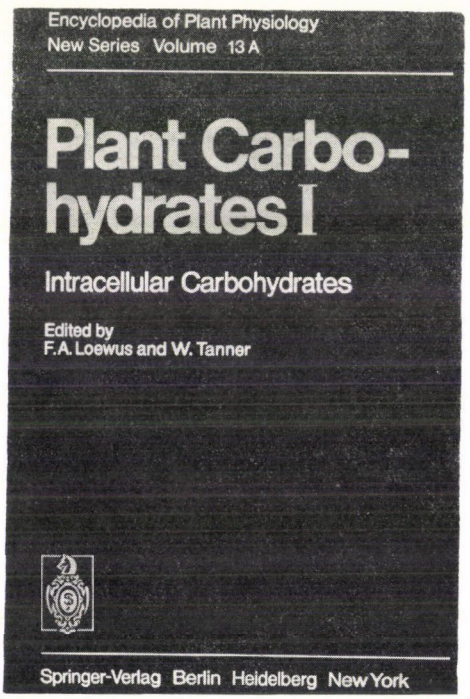
*

The reviewer has no easy task when trying to evaluate this chronicle of food economy in the last decade. For it is a true chronicle that he holds in his hand, one in which almost every sentence is verified by official factual data. The author's greatest merit, as I see it, is that he has always found the opportunity to express his own opinion. Thus, he does not simply publish statistical data, but gives utterance to his private views against a statistical background. His book may be of use to both internal and external observers of Hungarian food economy.

I. DIMÉNY

Plant Carbohydrates I. Intracellular Carbohydrates. Encyclopedia of Plant Physiology. New Series Vol. 13A. F. A. Loewus and W. Tanner Eds. Springer-Verlag, Berlin—Heidelberg—New York, 1982, pp. XIX + 918

Volume I of "Plant Carbohydrates" is divided into three sections: I. Monomeric and oligomeric sugars and sugar derivatives, II. Macromolecular carbohydrates and III. Physiological processes. The first chapter in Section I was written by D. S. Feingold on "Aldo (and keto) hexoses and uronic acids". This chapter deals exhaustively with carbohydrate interconversions, phosphorylation of free sugars, nucleotide sugars and deoxy sugars, and provides an integrated picture of the possible evolutionary significance of carbohydrate interconversion pathways. "Polyhydroxy acids: relation to hexose phosphate metabolism" was summarized by J. E. Gander. This chapter draws attention to the central role of D-glucose-6-phosphate in the metabolism of polyhydroxy acids, including myo-inositol, phytic acid and L-ascorbate. "Amino sugars — plants and fungi", including the biosynthesis of glycolipids and glycopeptides, were dealt with by L. Beevers. E. Beck summarized in detail the "Branched-chain sugars" (monosaccharides) in higher plants and microorganisms. Our recent knowledge on "Sugar alcohols" (mannitol, sorbitol, polyols, phosphate esters), including their metabolism and role in nature (e.g. osmoregulation), was reviewed by R. L. Bieleski. A review on "Cyclitols" (myo-inositol and its derivatives) was written by F. A. Loewus and D. B. Dickinson. A justifiably long chapter by G. Avigad was compiled on "Sucrose and other disaccharides". This review includes the biosynthesis, breakdown, transport, storage and utilization of sucrose and that of several other disaccharides. O. Kandler and H. Hopf wrote a chapter on "Oligosaccharides based on sucrose", a group of substances which may be called primary oligosaccharides synthesized by the action of a glucosyl transferase from mono- and oligosaccharides. These substances have a metabolic relevance (cf. their role in frost resistance) in contrast to the secondary oligosaccharides. A chapter devoted to the "Glycosylation of heterosides" was written by G. Franz.



In Section II, the first review is devoted to the "Biosynthesis of starch and its regulation", a central problem in plant physiology for the last century. The possible reactions, the so-called major route and its regulation, as well as the properties of the enzymes involved are very clearly described. Of no less interest for the specialist is the chapter by H. Meier and J. G. S. Reid on "Reserve polysaccharides other than starch in higher plants". The substances covered include the mannan group, the xyloglucans, the galactans and the fructans. The biological function of these polysaccharides is also dealt with, whenever possible. This chapter is well supplemented by the review by D. J. Manners and R. J. Sturgeon on the "Reserve carbohydrates of algae, fungi and and lichens". The very rapidly developing field, "Plant glycoproteins", was reviewed by R. R.

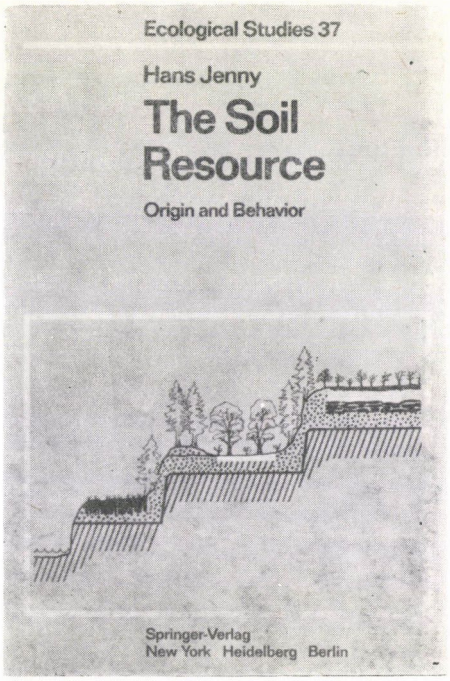
Selvendran and M. A. O'Neill. Purification, fractionation and characterization of (and structural studies on) these substances were critically reviewed. This is a crucial aspect of any reliable work in this area. Some of the better-defined glycoproteins and proteoglycans (agglutinins, lectins) were described in more detail. "Membrane glycoproteins" present perhaps the most fashionable group of glycoproteins. Their structure, biosynthesis and intracellular transport were covered by D. J. Bowles. Logically, a discussion of "Glycolipids and other glycosides", written by A. D. Elbein, follows the chapter on glycoproteins. This group of substances (glycosyl diglycerides, cerebrosides, phytoglycolipids, steryl glucosides) is of paramount importance for a number of biological membranes, including those of the photosynthetic tissues. A more detailed account, specifically on the "Steryl glycosides", was given by M. Axelos and C. Péaud-Lenoël.

Section III is introduced by a chapter on "Transport of sugar" written by E. Komor. Various types of membrane transport systems, their distribution in various species and organs and their quantitative significance are beautifully described. Sugar transport is logically followed by "Storage of sugars in higher plants", well presented by J. Willenbrink. The chapter is a re-evaluation of a century-old problem, based on modern concepts and new data. A classical problem of plant physiology, "Storage of starch", is revitalized by the up-to-date treatment of the problem by C. F. Jenner. Modern aspects also dominate in the next chapter by P. Halmer and J. D. Bewley on the "Control by external and internal factors over the mobilization of reserve carbohydrates in higher plants". The review is comprised of case studies, each dealing with the fate of a particular reserve carbohydrate in a specific storage organ.

The encyclopedic nature of the volume is in perfect harmony with the up-to-date presentation of the material. This is mainly achieved by the extensive use of tabulated material, which greatly helps the reader in easy orientation.

The phytochemist, bio-organic chemist and plant physiologist/biochemist, working not only on carbohydrates but with almost any plant biological material, will unavoidably need one or other chapter of this exceptionally rich volume. For the specialist the book is, clearly, a must. G. L. FARKAS

H. JENNY: *The Soil Resource — Origin and Behavior*. Springer Verlag, New York—Heidelberg—Berlin, 1980. 191 figures, 377 pages.



This book forms the 37th volume of Ecological Studies, a deservedly popular ecological series published by Springer-Verlag, and covers an important, timely subject. Nowadays, when there is an ever more urgent danger that our natural resources will run out, the utilization of solar energy is in the centre of interest. The extension and intensification of ecosystem research are in part connected with this. One of the main components of the ecosystem is the soil. The processes taking place in the soil fundamentally determine the amount of solar energy that can be built into the biomass. The importance of the soil has been known for centuries, nor is the modern approach to the subject unknown. In earlier volumes of Ecological Studies (Vols 1, 2, 4, 5, 6, 8, 10, 11, 15, 16, 17, 19, 26, 27, 29, 32 and 34) numerous data related with the subject were published, while Environmental Geochemistry: A Holistic Approach (Vol. 35) can be regarded almost as an integral preliminary and at the same time complement to the present book. In fact, numerous branches of science deal with the soil, partly in isolation and partly in co-ordination, with an interdisciplinary approach. Unlike the earlier practice the author used the latter method in writing a book taking a complex view of the subject.

This complex view is immediately obvious in Chapter 1 (Ecosystems and Soils), where — as a sort of introduction — the concept of the ecosystem is briefly outlined. In accordance with his main objective the author employs a spatial rather than a functional distribution of the ecosystem, dividing the ecosystem into "soil space" and aboveground "vert space". He then clarifies certain fundamental concepts which are subsequently used, including soil profile, soil horizons, and the tessera, which corresponds to a three-dimensional soil profile, or prism. In so far as it includes the vegetation, the latter is referred to as the ecotessera. The chapter continues with a short characterization of the colours, structural features and chemical properties of soils, and closes with a soil system made up of ten classes.

Chapter 2 surveys the water regimes of the soil and the vegetation. As a starting point the soil is regarded as a climostat capable of modulating external environmental effects. This manifests itself, for example, in a more balanced heat regime in the soil profile or in the formation of natural water reservoirs. The author then passes to the forms in which water is present, and to the physical and mathematical laws which govern this; he also discusses the fundamental questions of gravitational potential, sorptive potential, matric potential, capillarity, osmotic potential, etc., mentioning the ecosystem as a kind of continuation of this.

The following two chapters (Behavior of Ions in Soils and Plant Responses; Origin, Transformation and Stability of Clay Particles) give a description of soil structures starting from an ecophysiological characterization of the soil. In the course of this the author touches upon plant physiological questions such as the range of macro- and microelements, the question of transport between the soil solution and the roots, or the soil — root interaction.

The chapter Biomass and Humus starts with a somewhat oversimplified scheme of photosynthesis, and passes through a short characterization of the assimilation processes before arriving at the main point: the description of humus formation and demineralization. With regard to the latter, an abundance of new information is supplied. The next chapter (6) is a continuation of this subject.

The further chapters (8—14), under the title Soil and Ecosystem Sequences, reflect the complex view set as a target in the introduction. How does the ecosystem change and develop in time and space? What causes the differences between the ecosystems? These are some of the questions that the author sets out to answer by means of state factor analysis. This is illustrated by actual examples of the various phenomena. For instance, when analysing the time factor he uses the Alaskan model of tundra formation; when discussing soil genesis in the desert he describes the Mexican form of this. Many other typical examples are also mentioned. Native rock, as a state factor, is also a decisive factor in the development of the soil and the ecosystem. So-called zonal soils are formed over "normal", chemically balanced native rocks, such as granite, basalt, loess, etc., partly under the influence of the climate, and partly under that of the flora. Intrazonal soils, on the other hand, are formed on special "abnormal" native rocks, causing Ca or other deficiencies. This subject is also illustrated by the presentation of concrete examples. This chapter is followed by the analysis of topography as a state factor. There can be little doubt that the factors discussed here are of fundamental importance. The degree of exposure due to the topography modifies the local climate, the water regime, and consequently the quantities and spatial distribution of organic matter. The chapter deals with special problems too, such as the formation of extremely salty soils and the question of soil erosion. In relation with the latter the book gives many examples to show the damage occurring on forest and agricultural areas alike. Although references to the role of the climate are found in connection with all the previously discussed state factors, the separate discussion of the climate in chapter 12 is definitely warranted. The characteristics of the climate, the effects of seasonal changes, evapotranspiration and height above sea level are discussed through the presentation of concrete examples. Also, the climatic conditions required for humus formation and decomposition, and specific changes in the N- and C-cycles are described for particular sites (Sierra Nevada, Delhi, Himalayas, Canada, Mexico, etc.). The role of precipitation, and its influence on the accumulation and leaching of $CaCO_3$ and $MgCO_3$ and on the process of matter formation, are analysed in a separate section (Precipitation, Base Status, and Carbonate Regimes). The analysis of state factors is completed by a discussion of biotic factors. In this section the author starts from the response function for biotic factors, outlines the experiments (conventional and unconventional pot experiments) used in this field, then passes on to the biotic factors that play a decisive role in the development of the ecosystem. Among the effects of plants, the role of pioneer species, original and other plant associations, and the direction of changes in them are shown, through the analysis of examples from Alaska, Sierra Nevada, Alberta, Iowa, etc. The last chapter in this

range of subjects deals with the role of animals and humans.

In Chapter 14, which can be regarded as a kind of summary, the author emphasizes the correlations between the factors, with a simultaneous brief summing up of the basic principles.

This new volume in the Springer-Verlag ecological series is at the usual high standard. The figures well illustrate the relevant subject, and the mathematical approach to various regularities is definitely a novelty. However, the aim set out in the Preface: to compile an interdisciplinary book suitable for use by professionals trained in various fields, necessitates a certain amount of compromise. In many cases questions which would be obvious to a qualified expert require detailed explanation. It would perhaps have been more to the purpose to make references to earlier volumes in the series instead of the short, not very informative summaries. In Chapter 2, for instance, when discussing the water regime, an outstanding example of this is encountered. The description of the fixation and movement of water in the soil is oversimplified. Considerably more information is given on this subject in an earlier Springer-Verlag publication (Physiological Plant Ecology by W. Larcher). At the same time, probably due to lack of data, hardly anything is found about the specific water regime conditions developing in the different ecosystems. In a similar way, relatively little is said in some sub-sections of Chapter 3. For instance, the page and a half describing macro- and microelements gives no new information to the biologists and very little even to other experts interested in the subject. In the same way, ion uptake is a specifically plant physiological question, so its treatment within such a narrow framework is hardly justifiable. On similar considerations sections A, B, C and D of Chapter 5 could also have been omitted. What we learn here about photosynthesis and organic matter turnover would be more aptly found in a popular scientific magazine. The contrast is particularly great, since the last sections of this chapter, and the following chapters in particular, are of an extremely high standard and introduce really original subject matter. Though not a real deficiency, a more lengthy discussion of soil classification and of environmental pollution, e.g. by insecticides and herbicides, would have been welcomed. These latter may almost be regarded as state factors, since apart from their extremely drastic effects they modify the ecosystem in a relatively short time.

In spite of the objections listed above, this book maintains the high standard of the ecological series. As the author mentions in the Preface, biologists and practising agriculturists interested in the subject will find the book equally useful. H. Jenny's book "The Soil Resource" will certainly soon become one of the most widely read books on the subject.

J. BERNÁTH

R. J. HANKS—G. L. ASHCROFT: *Applied Soil Physics.* Springer-Verlag, Berlin—Heidelberg—New York, 1980.

Hanks and Ashcroft, professors at the Institute of Soil Science and Biometeorology of the Utah State University (USA), summarize in an up-to-date manner all that needs to be known about applied soil physics — particularly about the water and heat regimes of the soil — by university students of agriculture and water management, and by engineers in everyday practice. The 159-page book is divided into 5 chapters. The appendix lists the units of measurement discussed, and gives their dimensions and numerical values. The book also contains example and subject indexes.

The chapter dealing with the quantitative aspects of the water contained in the soil discusses the soil as a water-storing medium, and presents methods for calculating and measuring quantitative changes in the soil moisture. This chapter gives a model calculation of numerical changes of value in the components of the hydrological cycle during the vegetation period.

The chapter discussing water potentials is an excellent summarization from a theoretical point of view as well. It makes the basic statement that the water content of the soil is not in itself a sufficiently characteristic index.

The value of the water potential in the soil can be expressed by the amount of work performed by a unit amount of water moving within a system towards a water receptor. Within this formal definition the authors give a detailed description of the concepts of

— gravitation potential,
— matrix potential and
— pressure potential,

together with methods of calculating them.

The authors describe field and laboratory methods for determining the values of the matrix potential and pressure potential, and present the results obtained. They point out the possibilities of regulating irrigation by tensiometers and give excellent practical examples, while calling attention to the limitations involved in calculating measuring and applying these potentials. The concept of "solution potential", which is also discussed by the authors, is of special practical impor-

tance in the case of saline-alkali soils. An equation that expresses the salt concentration at which this solution potential can be determined is presented. The description of the procedure for assessing the water potential may be of interest to those applying it in Hungary and elsewhere.

After the water potentials, extremely important practical questions are dealt with in the chapter entitled "Water flow in the soil". Among other things, the relationship between hydraulic conductivity and matrix potential is discussed in the case of two soils with different water contents.

Within the subject of horizontal and vertical seepage the diffusion equation for horizontal flow is given, together with the solution. For vertical seepage the advantages of Philip's equation compared to others are discussed. According to the authors these advantages stem from the fact that the constants used in the equation are primarily physical rather than empirical.

A convincing mathematical description is given for the physical content of evaporation, including that of evaporation decreasing in time. An interesting practical view is revealed by the fact that the authors call attention to some practical methods of decreasing the evaporation.

The physical reasons for the motion of vapour in the soil are summarized in a highly effective way. They stress that the flow of vapour in the soil is mainly a function of temperature. The amount of water flowing in the soil in the form of vapour is small in the case of normal temperature gradients, whereas it is much larger on the soil surface, where the soil and the atmosphere make contact.

The chapter discussing the relationships between soil, plant and atmosphere gives a concise summary of the principal physical content of the system referred to in the title, and presents the major correlations concerning radiation and energy balance, as well as the possibilities of assessing or calculating the evapotranspiration from climatic and soil data. A separate section deals with the assessment and physical aspects of transpiration, which is more than just a physical phenomenon.

The last chapter in the book discusses the physical laws governing the processes which make up the heat regime of the soil. Some of the research results presented are already known, while some are more recent, but of general validity.

To sum up, it can be established that the book "Applied soil physics" written by Professors Hanks and Ashcroft, containing as it does a clear, logical summarization of research results obtained mainly in the USA and a very useful introduction to the calculation of practical examples, is an extremely valuable work.

The book can justly lay claim to the interest of those who desire to obtain a clear picture of the most important correlations in applied soil physics and how they can be put into practice. I. PETRASOVITS

J. PALTI: *Cultural practices and infectious crop diseases.* Springer-Verlag, Berlin—Heidelberg—New York, 1981. 243 p. with 43 figures.

This book, written by Dr. J. Palti of the Agricultural Research Organization (Bet-Dagan, Israel) and published recently as the 9th volume in the "Advanced Series in Agricultural Sciences", the first volume of which appeared in 1975, discusses the relationship between crop production practice and infectious crop diseases with a view to integrated control. The book is arranged on a decimal system and is divided into sections as discussed below.

Introduction

The development and state of health of a crop is always the result of the joint action of biological and environmental factors influenced by human activity. In other words: the state of health of crops is an extremely complex question. This book — quite rightly — deals with only one important group of agents affecting the health of the crops and the pathogens: cultural practices, which in themselves have a very complex effect on plants and their state of health. Thus, animal pests and physiological or meteorological factors causing physiological diseases are not discussed.

After an "Introduction" covering more than two pages the book is divided into three sections (Parts 1, 2 and 3) with the titles, subsections and contents briefly described below.

1. Climate, cropping and crop disease

Within the sub-section "Agro-ecosystems, the cultural practices they have generated, and the general impact of such practices on crop disease" the book deals with the humid agroclimate, including the humid cool, humid warm and wet tropical variants. In Fig. 1.1, adapted from Thorne and Thorne (1979), the author presents the major climatic zones of the Earth, for the sake of better understanding.

Areas with humid cool agroclimates, for example (including Hungary), where the growing season lasts 4—8 months, are char-

acterized by a cold winter. In countries situated on such areas the standard of agriculture is very high, particularly in Europe, North America and East Asia.

The cold winter characteristic of the humid cool agroclimate is less well tolerated by many plant pathogens than by their host plants. Nevertheless, the major pathogens are able to overwinter; for instance, a number of *Fusarium* species overwinter in the form of chlamydospores, the *Verticillium*, *Sclerotina* and *Sclerotium* species in the form of sclerotia, and fungi such as the pathogen of apple powdery mildew *(Podosphaera leucotricha)* in dormant host tissues.

On areas with warm humid agroclimates, such as the southern and south-eastern parts of the United States of America, South America, South Africa, China and Australia (Fig. 1.1), the favourable climate makes the cultivation of many crops or groups of crops possible throughout the year. Of the major industrial crops grown in these regions cotton and groundnut are damaged by the same soil-borne pathogens: *Verticillium dahliae* and *Sclerotium rolfsii*. The constant presence of host plants, and the absence of a cold winter period that would reduce the inoculum level represent the main control problem for farmers.

The wet tropical zone is situated on both sides of the equator on areas in America, Africa, Asia and Indonesia. In these regions the overabundant precipitation (1500 mm a year) ensures favourable conditions for endemic diseases which from time to time assume epidemic proportions. Therefore, on these areas phytopathological research has mostly been concentrated on the epidemiology of groundnut, coffee and tea plantations.

From the point of view of phytopathological problems the author distinguishes cool dry, warm dry and semi-arid climates within the concept of dry agroclimates.

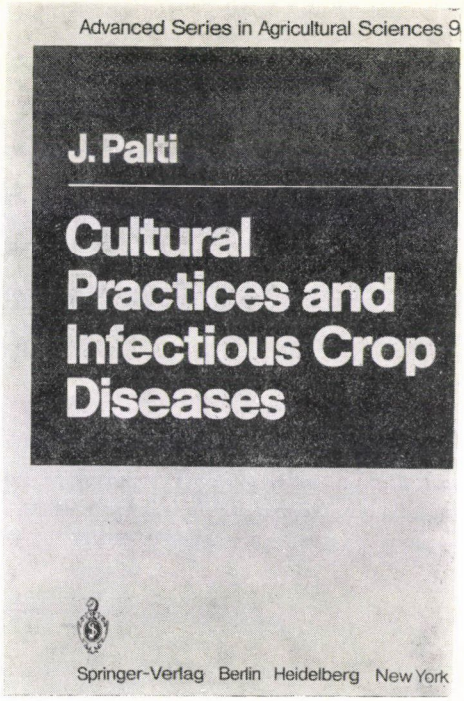
The future prospects of agroclimates and crop diseases are discussed by the author in three different categories. These are:

a) Agroclimates where one growing season is sharply separated from the next by a cold winter.

b) Agroclimates where the separation is achieved by drought.

c) Agroclimates where neither cold nor drought separate the growing seasons from one another, e.g. the warm humid and the wet tropical climates.

In the subsequent sub-sections the relationship between microclimate and crop climate are treated by the author on the basis of topography, soil type, density of plant cover and shade. The interrelations between macro-, micro- and crop climate on the one hand, and cultural practices on the other are



clearly seen in Fig. 1.2, while the effects of shade on the development of some tropical crop diseases are summed up in Table 1.2.

The control of crop diseases is approached by the author through the destruction of the inoculum, the different susceptibility of crops, the resistance of certain varieties, and the possibility of minimizing the reproduction and spread of pathogens. Further subjects dealt with in detail in this section are: soil, soil microbiotas, soil-borne pathogens, stress, strain and predisposition, age of plants, and the relation between weeds and crop diseases.

2. Major cultural practices and their effect on crop disease

The assessment of input cost, benefit and risk, and the complex nature of the choices available may result in various decisions on disease control. The author quotes the German saying: "He who has a choice must suffer for it".

In the 14 sub-sections in Part 2 the author discusses in detail the rules of plant hygiene, such as preventing inoculum from being introduced and spread, the removal and destruction of diseased plants, crop sequence, the advantages of black fallow, monoculture, soil amelioration and mulching,

soil cultivation, crop nutrition, water management, irrigation, sowing, planting, stand density, harvesting, harmful neighbour effects, grafting, budding and the application of physical barriers and optical means against vector-transmitted plant viruses.

As seen from the above, the author takes all the known measures of plant hygiene and cultural practices into consideration with a view to integrated plant protection.

3. Interactions between cultural practices, resistance breeding, and application of chemicals: integrated control

The integrated control of plant diseases is aimed, as is protection against animal pests, at keeping the damage caused by parasites at an economically acceptable level not only in individual crops but in the whole system of crop production, and not only in individual farms but over the whole of the farming community.

In order to achieve this aim both preventive and curative measures must be taken into consideration and integrated with each other and with indispensable cultural practices which are not primarily linked to disease control, such as nutrition and irrigation, or chemical pest and weed control.

The preventive measures consist mostly of breeding for resistance and agrotechnical plant protection, while the curative methods (which are mostly applied after the appearance of the disease) are represented almost exclusively by chemical control.

Figure 3.1 gives a very clear illustration of integrated control against barley powdery mildew *(Erysiphe graminis* f. sp. *hordei)*, after Jones and Clifford (1978).

In Part 3 of the book the author presents the experiences and achievements of many research groups in countries with developed agriculture, in order to show how agrotechnical plant protection, resistance breeding and chemical control, which is still indispensable, can be economically and successfully combined so as to result in a higher standard of integrated crop protection.

In the last sub-section in Part 3 (3.7) interesting ideas are found concerning the further improvement of integrated disease control and its components, with a view to increasing crop yields all over the world.

Special credit should be given to the author for the fact that, in spite of his own wide-ranging experience, he requested the assistance of co-authors and, judging by the three-page "Acknowledgements", took advice from a large number of institutions and individuals in order to perfect the book.

Besides the usual "References" (including papers by Hungarian authors: Farkas 1978, Király 1976, Mudich 1967) and the "Pathogen and Subject index" the book contains 43 figures and a list of French, German and Spanish equivalents of the English terms, thus making the book more suitable for international use.

Credit for J. Palti's book is due not only to the author, but also to the publishers, Springer-Verlag, who recognised the need for a work of this type. It is to be hoped that the ideas and methods presented in the book may result in a higher and more successful standard of integrated crop protection all over the world, which in turn, in addition to the protection of the biosphere, may lead to the relief of hunger, the most serious problem now facing the world.

I. MILINKÓ

RORISON, I. H.—HUNT, R. (eds): *Amenity grassland — an ecological perspective.* John Wiley and Sons. Chichester—New York—Brisbane—Toronto, 1980. 1—261. 25 figures.

This book, which is divided into 5 main sections with 14 chapters written by 14 authors, contains the material of a scientific meeting organized by Sheffield University and held between 11th and 13th December 1978 on the subject "Amenity grassland research — an ecological perspective".

In England all grass areas planted primarily for their aesthetic and recreational value, where production is only a secondary consideration, are understood by amenity grasslands.

With the increase in environmental and urbanizational damage the demand for semi-natural vegetation and grass areas under intensive cultivation to play an amenity role has come into increasing prominence.

The book gives a review of the floristic, ecological and management aspects of these grasslands on the basis of the most recent research results.

The book is divided into the following 5 main sections:

The first section (Introduction) defines the concept of "amenity grassland" and offers a survey of the amenity grasslands in England, including golf-courses, recreation grounds, tennis-courts, urban parks, nature conservation areas, country parks, military airfields, areas beside motorways, etc. There is a total of about 8,500 km^2 of such areas in England.

According to a survey by the "Amenity Grass Committee", research on amenity grasslands is necessary in the following fields:

1. standards of management and measurement

2. establishment and renovation
3. species and cultivar selection
4. mowing and growth control
5. fertilizing
6. wear
7. weed control
8. use of semi-natural areas.

The second section (Plants) acquaints the reader with the ecological characteristics (dominance, vegetation dynamics, regeneration ability, etc.) of the grass species to be taken into consideration when planning grass areas.

The frequency of six grass species *(Agrostis tenuis, Cynosurus cristatus, Festuca rubra, Holcus lanatus, Lolium perenne, Phleum pratense)* on the different biotopes (wetland, meadows, and pastures, arable, woodland, open habitats, spoil, wasteland) is presented in tabulated form. Further data are found on the frequency of grass species on grasslands under intensive cultivation, and on the frequency of occurrence at various altitudes, inclinations, exposure and soil pH values.

The production of new cultivars (e.g. those tolerant to heavy metals) is necessary, particularly due to the increasing environmental stress, but a fundamental requirement for this is the preservation of the genetic value of natural and semi-natural grasslands.

One chapter discusses the method of choosing species and cultivars, and deals with the morphological, physiological, etc. properties and criteria for utilization (rapid establishment, persistence, fitness for purpose, good appearance) demanded from the grasses forming amenity grasslands.

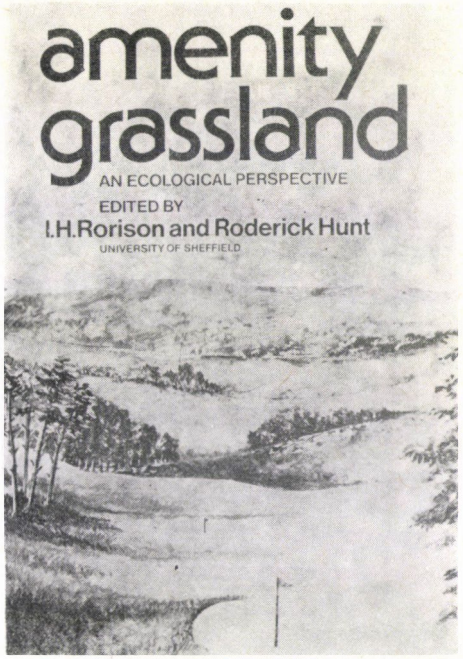
On the basis of investigations in England, Holland, West Germany and Denmark knowledge is presented on the use-value of grasslands.

The book gives the basic principles of how to choose the grass mixtures and lists the species suitable for grass areas used to various intensities.

The third section (Soils) discusses in four chapters the nutrient demands of grass species and the effect on species composition of the fertilizers applied. Detailed data are presented on the amount of nutrients obtained each year by mowing grasslands.

Information is given on changes in the nutrient contents of meadow soils, and on the input and output of the major nutrients, from which the nutrient balance of the soil can be determined.

In grassland management air pollution has also had to be taken into consideration recently. In response to the increasing SO_2 content of the air and the acidic precipitation in urban areas the pH value of the soil



decreases and the leaching of mobile elements (Ca, Mg) increases. Changes in the components of the soil affect the floristic composition of the grassland. The quantity of nitrogen reaching the ground with the precipitation also influences the nutrient balance of the soil.

Due to the climatic conditions in England, the large amount of precipitation means that most soils need draining. On the basis of experimental results levelling, drainage, canalization, etc. are suggested as preventive and rehabilitative technical procedures.

One chapter contains practical advice concerning the establishment of sport-turfs, describing in detail methods of sowing and fertilization and the routine maintenance operations.

As a consequence of mechanical damage and of wear caused by intensive treading, the floristic structure of the grasslands and many of the soil properties change. The book presents the grass species in order of tolerance to wear. The grasses most resistant to treading are *Lolium perenne*, *Poa annua*, *P. pratensis*, *Phleum pratense* and *P. bertolii*. The extent of wear can be simulated with various machines.

The fourth section (Usage and maintenance) discusses the tending of grasslands in four chapters.

For amenity grasslands which are used extensively one method of tending is mowing; various herbicides should be applied to control weed growth.

Since amenity grasslands include roadsides and nature conservation areas, particular consideration must be given to the ecological, phenological and life conditions of the grass species when maintaining and cultivating them.

For lowland grasslands a wide-spread method of management is grazing, the effect of which varies with the animal species (cattle, sheep, horses, etc.). The reader is offered a survey of different ways of mechanical mowing, of the effect of mowing at various times on the soil, of changes in pH value, organic matter content, K, Na, Mg, Mn and P contents, and of the consequences of burning grasslands.

The two chapters in the fifth section (Two overviews) deal with the economic and aesthetic value of amenity grasslands, classifying them on the basis of ownership, maintenance and usage.

The last chapter discusses the relationship between ecology and agronomy, emphasizing the importance of this relationship.

The book is complemented with brief summaries of the results of 15 scientific papers displayed at the meeting in the form of posters.

At the end of each chapter a detailed list of references is found, and the book is completed with name and subject indexes.

The book is important for botanists as well as for those engaged in grassland management, environmental protection and landscape designing. Although it chiefly discusses grasses suitable for the climatic conditions of Western Europe, giving information on their ecological requirements and cultivation methods, the new research results and principles can be adapted to the grassland management of areas in other climates as well.

M. Kovács

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EUPHYTICA

NETHERLANDS JOURNAL OF PLANT BREEDING

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Vol. 31 (1982) ca. 900 pages, containing 111 articles, among which:

Plant regeneration from callus culture in potato; Competition between 2× and × pollen in styles of *Solanum tuberosum*; The use of the topiary gene in adapting *Solanum* germplasm for the potatoe improvement; Evolutionarily persistent and evolutionarily stable strategies in plant pathosystems; Selection for yield in small plots of spring wheat; Exploitable genetic variation in composite bulk population of barley; Generation mean analysis to identify and partition the components of genetic resistance to *Septoria nodorum* in wheat; Studies on the self-incompatibility of *Petunia hybrida* in excised-style culture; The transfer of characters from *Brassica campestris* to *B. napus*; Natural male sterile mutant in chilli, *Capsicum annuum;* New sources of resistance to anthracnose and angular leaf spot of beans *Phaseolus vulgaris; Kalanchoe blossfeldiana* cultivars: their origin and development; Pollen and pollination experiments in pear; Stability of induced compact mutant clones of Bramley's Seedling apple; Barriers to interspecific hybridization in *Ulmus americana*.

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ACTA PHYTOPATHOLOGICA

ACADEMIAE SCIENTIARUM HUNGARICAE

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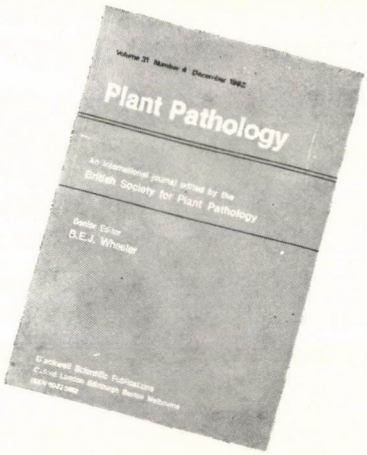

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ADOLF GUSZTÁV MANNINGER

1910–1982

The death of Prof. Adolf Gusztáv Manninger, emeritus professor of plant protection at Keszthely University of Agricultural Sciences, inflicted a grievous loss on the domain of agricultural entomology in Hungary.

He was born in Rácboly (Hungary) on 6th May 1910. Already as a child he was exposed to an intense agricultural atmosphere since his father was a highly educated agricultural expert working in leading positions on large estates, later becoming professor of plant production at the College of Agriculture in Debrecen, while his mother was the daughter of Sándor Cserháti, the founder of modern plant production and plant breeding in this country.

Manninger studied at the Faculty of Agriculture of the József Nádor University of Technical and Economic Sciences in Budapest. In 1934 he obtained a doctor's degree in plant production by a thesis on the biology and economic importance of cereal bugs. In 1937/38 he continued his studies at the Georg August University (Göttingen, Germany) mainly in pedology and plant production. Although his father wanted him to become a pedologist, he soon

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decided to concentrate all his scientific endeavours on the biology and control of field crop pests.

The talented young man began his career at agricultural high schools and colleges. In 1949 he became assistant professor of plant protection at the Keszthely Agricultural College, and in 1950 full professor at the University of Agricultural Sciences in Budapest (later Gödöllő). From 1957 to 1969 he headed the Department of Plant Protection Technology of the Research Institute for Plant Protection, Budapest. In 1969 he returned to Keszthely and chaired the Department of Plant Protection until he retired in 1976 which, however, did not mean the end of his scientific activities, since he continued to study his beloved science almost until his death.

Manninger was a unique personality in his professional field. Most scientists working in agricultural entomology concentrate their efforts primarily on the pest species, while the farmer's point of view often plays only a secondary role. By contrast, Manninger's approach was always characterized by a thorough consideration of each case primarily from the side of the farmer. This explains his unmatched achievements in developing pest control methods which were not only well grounded theoretically but were also immediately introduced into agricultural practice.

Field observations and experiments as well as large scale surveys on the occurrence of pest species were the essential tools used in his scientific work. Although he did not deny the importance of laboratory investigations, he preferred to work under natural conditions. There remained hardly any important field crop pest species which he did not deal with. During more than four decades he gathered an immense quantity of data on the biology of insect pests. Unfortunately, only a part of this treasury of biological information has been published in his works.

Pest insect forecast was his most cherished subject. He organized and led regular surveys across the country for estimating the population densities of various pest species with special regard to the pests of sugar beet, lucerne, maize, wheat, and industrial crops. The information derived from the surveys helped to develop new forecasting methods and means of control as well as to increase the economy of already available ones.

During the last decade of his life he paid increasing attention to the problem of environmental pollution, especially to that caused or potentially caused by the irresponsible use of pesticides. He emphasized that adequate forecasting methods make it possible to reduce the extent of pesticide application, i.e. to decrease the pesticide load of the environment without running into the danger of crop losses.

The results of his investigations were often published immediately, mostly in Hungarian agricultural journals of very wide circulation, so that his findings could be transferred into practice without delay. The extent of

his publishing activity (279 publications including books) indicates his unique capacity for work.

Manninger was an excellent and very conscientious professor who paid great attention to all the problems of his students. His lectures were thoroughly prepared and exemplarily demonstrated. His ardent enthusiasm for agricultural entomology caused many young men and women to choose this domain of science as their speciality. Manninger often helped his students to find a suitable job and kept an eye on their careers to help them whenever needed. A large number of excellent plant protection experts working in agricultural agencies, production, and education, as well as several well known scientists in this field came from among his students.

His scientific achievements were also well known abroad, particularly in the neighbouring countries where he was often invited to attend congresses and to give university lectures.

As an acknowledgement of his scientific and educational work he was awarded, among others, the Medal of the People's Republic (1951), the Kossuth Prize (1954), and the Gold Medal of Labour (1981).

With his death the ranks of an exceptional generation of Hungarian agricultural scientists have been thinned once again. But his memory is perpetuated in his numerous writings and it will never fade in the hearts of those who had the good fortune to know him.

T. JERMY

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THE ROLE OF TITANIUM IN PLANT LIFE V. THE EFFECT OF TITANIUM ON THE GROWTH OF TOBACCO CALLUS

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The authors studied the effect of titanium on the growth of plant callus. The microelement titanium was applied in the form of Pais—Fehér's Titavit (titanium chelate). The experimental plant material consisted of a secondary tobacco tissue culture of standard growth cultured on Murashige—Skoog (1962) medium under 16-hour artificial illumination at 25 ± 2 °C for 4 weeks. According to the results of experiments performed with a concentration series (0.5–20.0 mg/l) of Titavit, the action of the microelement on the growth of the callus depended on the concentration. The greatest activity was displayed at a concentration of 2 mg/l, stimulating the weight increase by 46% compared to the control. The 5.0 mg/l concentration caused inhibition and the 10 mg/l concentration necrosis. Changes in the unit weight (g) of cells followed the same tendency as the fresh weight, while the percentage change in dry weight showed the opposite tendency. The growth inhibition of culture media deficient in IAA and Kin, phytohormones directly influencing cell division, was compensated for by 2 mg/l Titavit. The theory that the microelement titanium—through an as yet unknown mechanism—exerts a hormone-like effect on the growth of plant tissues therefore seems well-founded.

Introduction

The culture media of plant tissue cultures generally contain building elements or metabolism regulators. The microelement titanium is not placed in either group by the literature, although it is present in certain microelement stock solutions (Gautheret 1959, Murashige—Skoog 1962, White 1943). The biological importance of titanium is generally considered negligible, since it occurs in about 10^{-4} per cent quantities in the plants, and the amount taken up under natural conditions in the field has no toxic effect. However, this can probably be explained by the fact that between pH values of 4 and 8 a large proportion of the titanium compounds occurring in the soil are insoluble, and thus unavailable to plants (Pais 1980). On the other hand, according to the results of recent investigations, the titanium salts available to the plants may inhibit the weight increase of the organs (Wallace *et al.* 1977) while stimulating the growth of certain plants (Dobrolyubovskij 1961, Rutshkaya 1971). The latter was proved, in particular, in the course of investigations carried out by a research team at the Chemical Department of the University of Horticulture, Budapest, where a titanium chelate known as Titavit, a water-soluble titanium salt available to plants, considerably increased the yield of wheat, sugar-beet, lucerne, maize, sunflower, tomato,

paprika, root-crops, legumes, various fruits and grapes when sprayed onto the leaves of the plants (DUDA *et al.* 1978, FARKAS *et al.* 1981, FEHÉR *et al.* 1980, 1982, PAIS 1974, 1979, PAIS—FEHÉR 1977, PAIS *et al.* 1969, 1975, 1977, 1978a, b, 1979).

This paper gives an account of work conducted in order to trace the action of titanium on the growth of plant tissues by applying a concentration series to isolated callus cultures.

Materials and methods

To test the effect of the microelement titanium secondary cultures of tobacco (*Nicotiana tabacum* L.) callus were used. The experimental plant material has been kept under culture in our laboratory through continuous reinoculation for some twenty years. The culture is a yellowish green group of cells that has completely lost its organization potential, and shows a steady rate of growth on a standard basic culture medium. In addition to the macro- and microelements used by MURASHIGE—SKOOG (1962) the basic culture medium applied contained 0.1 mg aneurine, 0.5 mg nicotinic acid, 0.5 mg pyridoxine, 2.0 mg glycine, and as hormones 2.0 mg β-indoleacetic acid (IAA), 0.2 mg kinetin (Kin) and 1.0 mg gibberellic acid (GA) per litre. In some variants culture media deficient in IAA or Kin were used. The concentration of agar was 0.8% and that of saccharose 30 g/l; the pH was adjusted to 5.8 prior to autoclaving. To this culture medium titanium was added at various concentrations (0.5–1.0–2.0–3.0–5.0–10.0–20.0 mg/l) in the form of Pais—Fehér's Titavit (titanium chelate, Ti); then the culture medium was sterilized for 30 min at 120 °C under 1 bar overpressure, and dosaged.

The 200 mg callus inocula grew in 25 ml culture medium for 4 weeks at 25 $\pm$ 2 °C with a 16-hour light, 8-hour dark photoperiod. Illumination was supplied by 3 Orion 20 W F.7—Daylight and 3 Tungsram 20 W F.33-White fluorescent lamps. Each variant consisted of 10 test-tubes. To check the effect of titanium the fresh weight and dry matter content of the cultures and the number of cells per g unit weight were recorded and the values of daily growth and relative weight (the multiplication of the weight of the initial callus) were calculated. The standard error of the data was also determined and expressed as a percentage of the control (MARÓTI 1976, MARÓTI—BOGNÁR 1980, TÓTH—MARÓTI 1979).

Results

The results of the experiments have been summarized in three tables and two figures. The growth data for the control, consisting of cultures grown on a basic culture medium containing IAA, Kin and GA, are realistic, agreeing with the growth indices for callus cultured for several years under the experimental conditions.

Titavit influences the increase in the fresh weight of tobacco callus as a function of concentration (Table 1). The result is a maximum curve; 1–3 mg/l stimulate growth, while higher concentrations inhibit it. A concentration of 2 mg/l is the most efficient, causing a weight increase 46% higher than in the control, while 10 mg/l Titavit necrotizes the cells, and the callus even loses some of its original weight. This is clearly shown by the weight data expressed as a percentage of the control, as well as by the calculated data of daily and relative growth.

Table 1

Effect of various Titavit concentrations on the growth of tobacco callus
Basic culture medium: Murashige—Skoog (1962); IAA, Kin, GA at the concentrations indicated
Incubation time: 4 weeks; temperature: 25 ± 2 °C

Hormones, mg/l		Titavit, mg/l		Fresh weight g/tube	% of control	Dry weight %	% of control	Cell number 10^3/g	% of control	Daily increase mg	% of control	Relative increase
		0.5	$\bar{x}$	2.713	89	0.69	109	2739	104	89.75	57	12.56
			±s	0.013				220				
		1.0	$\bar{x}$	3.386	111	0.61	97	2817	107	113.78	112	15.93
			±s	0.047				281				
IAA	2.0	2.0	$\bar{x}$	4.438	146	0.59	94	3798	144	151.35	149	21.19
			±s	0.010				379				
Kin	0.2	3.0	$\bar{x}$	3.295	108	0.70	111	2691	102	110.53	109	15.47
			±s	0.026				130				
GA	1.0	5.0	$\bar{x}$	1.144	38	0.71	113	2932	111	33.71	33	4.72
			±s	0.036				225				
		10.0	$\bar{x}$	0.192	6	0.81	128	1874	71	—	—	—
			±s	0.014				989				
		20.0	$\bar{x}$	0.163	5	0.80	127	2016	76	—	—	—
			±s	0.002				583				
Control		Control	$\bar{x}$	3.044	100	0.63	100	2640	100	101.58	100	14.22
			±s	0.014				175				

$\bar{x}$ = average; ±s = standard error

The percentage values of dry weight show a tendency virtually opposite to the trend in fresh weight. The lowest dry matter content was obtained with the concentration (2 mg/l) causing the most intensive increase in fresh weight, while in response to lower or higher concentrations the proportion increased. The dry matter content was particularly high in the case of variants causing necrosis (10–20 mg/l).

The number of cells counted in 1 g of fresh weight gives a curve similar to that of the fresh weight, except that even concentrations causing necrosis reduce the number of cells by only 24–29% compared to the control. This means that the weight and volume of cells per unit weight increased, primarily due to the large vacuoles and their high water content. This fact is fully confirmed by the percentage data of dry weight. Percentage changes in the three metabolic indices compared to the control are seen in Fig. 1.

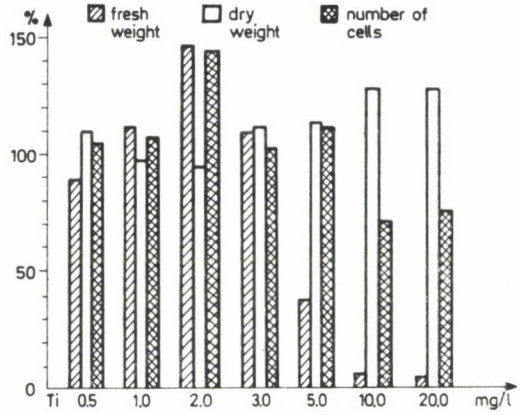

Fig. 1. Effect of Titavit (Ti) concentrations on changes in the weight and cell number of tobacco callus, as expressed as a percentage of the control

Table 2

Role of Titavit in the growth of tobacco callus
Basic culture medium: Murashige—Skoog (1962)
Incubation time: 4 weeks; temperature: 25 ± 2 °C

Hormones, mg/l		Titavit, mg/l	Fresh weight			Dry weight %	Cell number			Daily growth			Relative growth
				g/tube	% of control			10^3/g	% of control		mg	% of control	
IAA	—		$\bar{x}$	4.296	141	0.79	$\bar{x}$	2396	91	$\bar{x}$	146.28	144	20.48
Kin	0.2	2											
GA	1.0		±s	0.016			±s	202					
IAA	2.0		$\bar{x}$	2.350	77	0.98	$\bar{x}$	4124	156	$\bar{x}$	76.78	76	10.75
Kin	—	2											
GA	1.0		±s	0.016			±s	1086					
IAA	2.0		$\bar{x}$	2.386	78	0.64	$\bar{x}$	3487	132	$\bar{x}$	78.07	77	10.93
Kin	0.2	2											
GA	—		±s	0.014			±s	360					
IAA	2.0		$\bar{x}$	3.044	100	0.63	$\bar{x}$	2640	100	$\bar{x}$	101.58	100	14.22
Kin	0.2	—											
GA	1.0		±s	0.014			±s	175					

$\bar{x}$ = average; ±s = standard error

Table 3

The hormone-like effect of Titavit on the growth of tobacco callus
Basic culture medium: Murashige—Skoog (1962)
Incubation time: 4 weeks;
temperature: 25 ± 2 °C

Hormones, mg/l	Fresh weight as a percentage	Daily growth of the control
IAA 2.0 Kin 0.2 GA 1.0	100	100
IAA — Kin 0.2 GA 1.0	80	76
IAA 2.0 Kin — GA 1.0	34	27
IAA — Kin 0.2 GA 1.0 Ti 2.0	141	144
IAA 2.0 Kin — GA 1.0 Ti 2.0	77	76

To check the stimulative effect of Titavit on weight increase an experiment was set up which showed the interaction between the most effective Titavit concentration (2 mg/l) and the hormone-deficient variants of the basic culture medium (Table 2), and in which the hormone-deficient variants of the basic culture medium were compared among themselves (Table 3).

According to the data in the two tables the absence of IAA and Kin, hormones directly responsible for cell division, decreased the effect of the basic culture medium on growth by 20 and 66%, respectively, compared to the control medium which contained both hormones. The greater reduction of weight was caused by the absence of Kin. However, when Titavit was added to these hormone-deficient culture media at the most effective concentration (2 mg/l), the growth of the callus increased very noticeably in both deficient variants: in the Kin-deficient variant from 34 to 77%, and in the IAA-

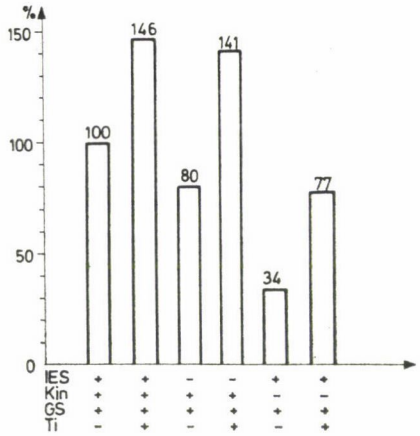

Fig. 2. Effect of Titavit (Ti) on the increase of the fresh weight of tobacco callus, as expressed as a percentage of the control. IAA = indole-acetic acid; Kin = kinetin; GA = gibberellic acid

deficient variant from 80 to 141% compared to the control. That is, the latter substantially exceeded even the 100% growth rate of the control. The fresh weight data for variants with a full hormone content complemented with 2 mg/l Titavit also show a 46% increase in growth due to the influence of Titavit (Fig. 2). The dry weight and cell number values of IAA- and Kin-deficient variants complemented with Titavit are generally higher than those of the control. This postulates a higher dry matter content and a larger number of cells with lower weight and volume per g unit weight. It may thus be concluded that cell division is more intensive.

The results of experiments with both a series of Titavit concentrations and with hormone-deficient culture media complemented with Titavit suggest that the microelement titanium exercises a hormone-like effect on the growth of tobacco callus. This effect is shown partly by the intensity of the weight increase compared to the control and partly by the fact that Titavit counterbalances the reduced growth caused by the absence of hormones in the culture medium, compensating particularly for inhibition by the IAA-deficient culture medium.

The experiments do not explain the mechanism of this effect of titanium, but simply confirm the data in the literature reporting on its stimulative effect on the growth of certain plants. DOBROLYUBOVSKIJ (1961), for example, observed an increase in the chlorophyll and sugar contents of vine leaves in response to titanium salt. RUTSHKAYA (1971) noted the favourable effect of titanium compounds on sugar-beet. PAIS and his research team found in experiments covering several years that under the influence of titanium the photosynthesis, the chlorophyll content and the activity of a number of

enzymes increased in the leaves, resulting in a more intensive growth of plants, the better utilization of basic fertilizers, and larger yields (DUDA *et al.* 1978, FARKAS *et al.* 1981, FEHÉR *et al.* 1980, 1982, PAIS 1974, 1979, PAIS—FEHÉR 1977, PAIS *et al.* 1969, 1975, 1977, 1978a, b, 1979).

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THE EFFECT OF POTASSIUM FERTILIZATION ON THE NUTRIENT UPTAKE OF WINTER BARLEY (MV 35) ON A CALCAREOUS SANDY SOIL

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The dynamics of nutrient content and nutrient uptake of the winter barley was investigated during vegetation period in field experiment. K-fertilization increased the AL-soluble K-content of the soil, the dry matter accumulation and the K-content, decreased the Ca content in all the phenophases. The dry matter accumulation continued till the end of the vegetation period. The nutrient contents in the plant decreased after tillering. The macroelements uptake was more intensive in the vegetative period while that of microelements—except Mn—on the generative period.

The growth of plants is determined by the conjugate effect of several factors. One of these factors is nutrition, which regulates considerably the quantity and quality of the crop. It is known that plant nutrition proceeds chiefly through the roots, and is in close connection with the conditions, availability and supply of nutrients in the soil.

For the characterization of the nutrient state, including the nutrient supply of the soils, soil and plant tests are equally used. The advantage of plant tests is that general methods can be used under different climatic and soil conditions. But this method also has some disadvantages: there are differences between the nutrient contents of certain parts of the plants, between the growth stages, the species, between plants grown in different years, etc., which make the interpretation of experimental results more difficult.

To estimate the fertilizer requirement it is essential to know the nutrient uptake of cultivated plants. Nutrient uptake analyses help to determine the quality and quantity of the necessary fertilizer and data on the rate of uptake help to fix the time of application.

According to the literature and to the current data the amount of nutrients is usually highest in the early stage of plant growth, while this amount decreases during the intensive stage (MENGEL 1979, COIC 1965, ANDRIESH—GOZHINETSKAYA 1976, TSERLING 1978, ELEK—KÁDÁR 1975, KÁDÁR—LÁSZTITY 1979, LÁSZTITY—KÁDÁR 1978).

Fairly good connections were found by several authors between the nutrient content of plants and the nutrient availability of soils (BERGMANN—NEUBERT 1979, BOLDYREV 1970, TSERLING 1978). In the present paper the

changes in dry matter accumulation and in the content and uptake of mineral elements were investigated during the vegetation period in a field experiment where the nutrient supply of the soil was diverse with respect to potassium.

Materials and methods

The experiment was carried out with 3 replications at the Experimental Station of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences in Őrbottyán in 1974.

The soil of the experiment was a slightly humous, calcareous sandy soil, with medium phosphorus (80–120 ppm AL-P_2O_5) and low potassium (40–60 ppm AL-K_2O) content. The data of the soil analysis were as follows: $pH_{KCl} = 7.5$; humus = 0.9–1.2%; $CaCO_3 = 1–5\%$; $Mg_{KCl} = 35$ ppm; $Mn_{EDTA} = 65$ ppm; $Zn_{EDTA} = 1.5$ ppm; $Cu_{EDTA} = 0.8$ ppm. According to the limit values and methods adapted in Hungary these data indicate that the Mn, Zn and Cu of the soil was sufficient, while that of Mg was low (DEBRECZENI 1980).

On a basis of $N_{160}P_{120}$ kg/ha, 0, 100, 450 and 750 kg/ha K_2O fertilizer was applied to study the effects of several years. The potassium fertilizer was applied in the first year of the experiment (1974/75) and the nitrogen and phosphorus annually. Nitrogen was applied by halves in autumn and spring, phosphorus and potassium in autumn. During the vegetation period samples were taken from the plants on 4 metres per plot. The dates of sampling were fixed according to the data in the literature and our own experience, and samples were thus taken during the following phenophases: tillering, shooting, earing, flowering and full ripening. The dates coincided with the national averages determined by VARGA-HASZONITS (1973), and usually represented periods of three weeks.

In the first years the test plants were winter wheat, sudangrass and maize.

In 1978 the test plant was winter barley, the significance of which is great and ever increasing in various countries (REINER *et al.* 1977, AUFHAMMER 1980, FROIDMONT 1976). Among the Hungarian species the fodder barley Mv 35, which has good crop parameters, was sown (POLHAMMER 1975). The samples were analysed with the methods usually applied in the Fertilizer Department of the Research Institute for Soil Science and Agricultural Chemistry, i.e. after digestion with $H_2O_2 - H_2SO_4$ nitrogen was determined by sodium hypobromite titration with a dead-stop indication of the end-point (FÜLEKY 1970), phosphorus by spectrophotometry (THAMM *et al.* 1968) and the microelements (Fe, Mn, Zn, Cu) by atomic absorption photometry.

The results of the plant analyses are given as the elemental nutrient contents of the absolute dry plant material. The samples were weighed and all the data, together with the results of the analysis, were evaluated by an analysis of variance using an H.P. computer.

Results and discussion

Due to the effect of fertilization the available AL-P content of the soil increased to 130–150 ppm on average. There was no significant difference between the separate treatments. The available AL-K content, however, differed significantly in the single treatments in the year of sampling as well. In the treatments the lowest AL-value was 66 ppm K_2O, the highest 99 ppm in the treatment with maximum fertilizer doses. The dry matter accumulation of winter barley (Table 1) continued almost consistently to the end of the vegetation period. The accumulation accelerated after shooting, when the dry weight produced increased by more than 3 t/ha between the separate periods.

Table 1

Accumulation of dry matter in Mv 35 winter barley during the vegetation period Őrbottyán, 1978 (dry matter t/ha)

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
160	120	—	0.464	1.130	3.467	6.745	3.25	3.11	6.36
160	120	100*	0.482	1.279	3.947	6.763	3.79	3.48	7.27
160	120	450*	0.516	1.324	4.760	7.457	3.58	3.31	6.89
160	120	750*	0.545	1.990	5.540	8.840	4.93	4.02	8.95
	$LSD_{5\%}$		0.177	0.459	0.990	1.710	1.25	0.89	1.96
	Mean		0.502	1.431	4.454	7.450	3.89	3.48	7.37
	%		7	19	60	101	53	47	100

* = autumn 1974

Due to potassium fertilization a tendency towards more intensive growth and, as an effect of the maximum fertilizer doses, a definite intensive growth of the plants were observed in almost all the phenophases (in proportions from 20–75%).

On average the increase between the separate phenophases was the highest after the period of tillering, when the dry matter weight multiplied three times. The N% content of winter barley (Table 2) decreased in the vegetation period from tillering to harvest, being only 16% at harvesting compared to the value at tillering. The quantity of nitrogen taken up increased parallel to dry matter accumulation (Table 2). The N-uptake doubled after the period of tillering but slowed down in the following phenophases, reaching only 12% of the total uptake in the generative period. After flowering, because of the nutrient redistribution, 2/3 of the nitrogen accumulated in the grain, the remainder in the straw. Due to K-fertilizer application, in the case of maximum dose treatments, the dry matter increase resulted in a significant surplus (30–40%) in the uptake from shooting to flowering, while at the beginning and end of the vegetation period only an increasing trend in uptake could be observed.

The P% content of winter barley showed less of a decrease from tillering to harvest than that of nitrogen (Table 3). Taking the P-content at tillering as 100, it decreased and/or was diluted to 35%, especially in the straw yield. K fertilization did not influence the phosphorus content of the green plant or that of the plants at harvest. The quantity of elemental phosphorus extracted by the plant (Table 3) gradually increased parallel to dry matter accumulation

Table 2

Changes in the N content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
					N, %				
160	120	—	5.71	3.89	1.77	1.12	1.93	0.53	1.25
160	120	100	5.73	4.03	1.59	0.99	1.83	0.47	1.18
160	120	450	5.83	3.46	1.49	1.00	1.51	0.43	0.99
160	120	750	5.88	3.62	2.01	1.39	1.96	0.45	1.53
	$LSD_{5\%}$		0.46	0.53	0.48	0.44	0.45	—	—
	Mean		5.79	3.75	1.71	1.13	1.81	0.47	1.24
	%		100	65	30	20	31	8	21
					N, kg/ha				
160	120	—	26.5	43.2	59.3	75.0	63.2	16.5	79.7
160	120	100	27.5	50.9	61.9	67.1	69.1	16.4	85.5
160	120	450	30.3	45.2	71.8	74.8	54.1	14.2	68.3
160	120	750	32.0	70.9	110.6	127.3	95.2	18.0	113.2
	$LSD_{5\%}$		10.3	11.6	28.2	51.5	25.5	4.1	18.3
	Mean		29.1	52.5	75.9	86.1	70.4	16.3	86.7
	%		34	61	88	99	81	19	100

throughout the vegetation period. The intensity of uptake was the greatest after the period of tillering and shooting, when half the total quantity was taken up by the plant. In the following phases the rate slowed down. At ripening 4/5 of the quantity taken up could be found in the grain, the remainder in the straw. The effect of potassium, which resulted in dry matter accumulation, showed a significant surplus in phosphorus uptake in the period of shooting and earing as well.

The decrease in the K content (Table 4) of the test plants during the vegetation period is almost the same as that of nitrogen. The K content of the plants at harvest was 27% of that at tillering. The data showed a strong enrichment in the straw. Potassium fertilization increased the K concentration of the green plant and the straw in all phenophases, in the case of higher

Table 3

Changes in the P content and uptake of Mv 35 winter barley during the vegetation period Örbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
					P, %				
160	120	—	0.50	0.45	0.29	0.22	0.39	0.051	0.22
160	120	100	0.46	0.44	0.27	0.22	0.40	0.047	0.23
160	120	450	0.51	0.47	0.27	0.21	0.42	0.047	0.24
160	120	750	0.49	0.42	0.27	0.22	0.40	0.059	0.24
	$LSD_{5\%}$		0.07	0.08	0.07	0.03	0.03	—	—
	Mean		0.49	0.45	0.28	0.22	0.40	0.051	0.23
	%		100	92	57	45	82	10	47
					P, kg/ha				
160	120	—	2.3	5.1	10.0	14.8	12.7	1.6	14.3
160	120	100	2.3	5.6	10.5	14.7	15.3	1.6	16.9
160	120	450	2.7	6.4	13.0	15.9	15.0	1.6	16.6
160	120	750	2.7	8.4	14.9	18.6	19.9	2.4	22.3
	$LSD_{5\%}$		1.2	2.7	4.1	5.1	5.1	0.4	3.6
	Mean		2.5	6.4	12.1	16.0	15.7	1.8	17.5
	%		14	37	69	91	90	10	100

doses significantly, by as much as 25–50%. The data for potassium uptake (Table 4) show, similarly to those for winter wheat, that the uptake reaches a maximum at earing, exceeding by 1/3 the uptake during the harvesting period. The intensity of uptake was the greatest when the plant was young, during the period of earing, when half the quantity was taken up by the plant. In the generative stage, due to nutrient redistribution in the plant, more than 70% of the quantity taken up could be found in the straw. The significant effect of potassium fertilization, which increased the uptake, could be proved mathematically in all phenophases, mainly in the case of higher doses. The increase in uptake was the result of dry matter accumulation and of an increase in concentration. The effect of higher potassium doses manifested itself in surplus uptake mainly in the green plant and in the straw.

Table 4

Changes in the K content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
					K, %				
160	120	—	2.72	2.58	1.61	0.74	0.51	1.05	0.77
160	120	100	3.36	3.11	1.68	0.82	0.48	1.03	0.75
160	120	450	4.01	3.69	1.75	0.89	0.55	1.28	0.90
160	120	750	4.05	3.91	2.04	1.14	0.52	1.43	0.93
	$LSD_{5\%}$		1.00	0.99	0.43	0.19	0.12	—	—
	Mean		3.54	3.32	1.77	0.90	0.52	1.20	0.85
	%		100	94	50	25	15	33	24
					K, kg/ha				
160	120	—	12.9	29.8	56.3	49.3	16.5	32.7	49.2
160	120	100	16.6	40.9	66.8	55.5	18.4	35.8	54.2
160	120	450	20.8	50.1	85.3	66.4	19.7	42.4	62.1
160	120	750	22.1	77.7	114.1	97.7	25.7	57.2	82.9
	$LSD_{5\%}$		6.5	24.5	28.2	26.4	9.4	10.3	9.9
	Mean		18.1	49.6	80.6	67.2	20.1	42.0	62.1
	%		29	80	130	108	32	68	100

The Ca and Mg contents of winter barley (Tables 5 and 6) also decreased from tillering to harvest, similarly to those of other winter cereals (LÁSZTITY—KÁDÁR 1978, ELEK—KÁDÁR 1975, LÁSZTITY—ELEK 1980).

Taking the Ca and Mg contents of the plants at tillering as 100, Ca decreased to 13% and Mg to 34% during the period of full ripening. Potassium fertilization caused mathematically significant changes in the Ca and Mg contents, probably due to the antagonistic effects among these elements. The Ca content decreased by 10–40% in the individual stages, due to the effect of potassium fertilization. The Mg concentration decreased significantly in young plants treated with K, during the periods of tillering and shooting. In the following stages no substantial changes could be proved.

The Ca uptake of winter barley (Table 5) showed an interesting picture. A quick, strong increase in uptake could be observed until the phenophase of

Table 5

Changes in Ca content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
					Ca, %				
160	120	—	1.25	1.04	0.56	0.26	0.052	0.35	0.19
160	120	100	1.34	1.04	0.37	0.20	0.046	0.29	0.16
160	120	450	1.19	0.75	0.39	0.16	0.041	0.27	0.15
160	120	750	1.18	0.79	0.45	0.17	0.046	0.24	0.13
	$LSD_{5\%}$		0.15	0.24	0.05	0.08	0.033	—	—
	Mean		1.24	0.95	0.44	0.20	0.046	0.29	0.16
	%		100	76	35	16	0.04	23	13
					Ca, kg/ha				
160	120	—	5.7	11.6	19.5	17.5	1.7	10.9	12.6
160	120	100	6.4	13.0	14.7	14.0	1.8	10.1	11.8
160	120	450	6.0	10.0	19.3	11.9	1.5	8.8	10.3
160	120	750	6.4	15.8	25.3	15.0	2.3	9.6	11.9
	$LSD_{5\%}$		2.0	4.0	6.6	5.5	0.9	2.9	3.1
	Mean		6.1	12.6	19.7	14.6	1.8	9.8	11.6
	%		53	108	169	126	16	84	100

shooting, exceeding almost by half the total quantity found at harvest time. After earing a gradual decrease followed until harvest. Due to the result of rearrangement in the plant, 9/10 of the total Ca content migrated into the straw and the remainder into the grain. The effect of potassium fertilization was demonstrable during the whole vegetation period and was mathematically significant in the shooting stage.

The Mg uptake (Table 6) was considerable even in the vegetative period and increased rapidly especially after shooting. At ripening the uptake slowed down and about 70% of the total was in the grain. K fertilization caused an inhibition in Mg uptake especially in young plants at tillering. In the other phenophases, in the case of maximum K doses, the Mg uptake increased, mainly due to dry matter increase. The parts of the plant above the soil surface showed decreasing microelement (Fe, Mn, Zn, Cu) contents (Tables 7,

Table 6

Changes in Mg content and uptake of Mv 35 winter barley during the vegetation period Örbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
kg/ha									
					Mg, %				
160	120	—	0.29	0.23	0.13	0.10	0.12	0.07	0.10
160	120	100	0.28	0.20	0.11	0.09	0.13	0.05	0.09
160	120	450	0.25	0.15	0.11	0.11	0.11	0.06	0.08
160	120	750	0.22	0.16	0.12	0.10	0.12	0.07	0.10
	$LSD_{5\%}$		0.03	0.04	0.03	0.01	0.02	—	—
	Mean		0.26	0.18	0.12	0.10	0.12	0.06	0.09
	%		100	69	46	39	46	23	34
					Mg, kg/ha				
160	120	—	1.4	2.5	4.6	7.4	3.9	2.2	6.1
160	120	100	1.3	2.5	4.2	6.3	4.9	1.6	6.5
160	120	450	1.3	1.9	5.4	8.0	3.9	1.9	5.8
160	120	750	1.2	3.2	6.6	9.1	5.9	2.8	8.7
	$LSD_{5\%}$		0.5	0.6	2.2	2.7	1.6	1.5	2.8
	Mean		1.3	2.5	5.2	7.7	4.6	2.1	6.7
	%		19	37	78	115	69	31	100

8 and 9) during the vegetation period. Taking the contents at tillering as 100, the values fell to 14 for Fe, 32 for Mn, 43 for Zn and 50 for Cu at harvest time. Potassium fertilization did not influence the changes in microelement contents in any of the phenophases. Microelement uptake (Tables 7, 8, 9 and 10) was more intensive during the generative period, with the exception of Mn, which showed the same phenomenon in the vegetative stage. The Mn uptake continued till flowering, while the uptake of the other elements lasted till the end of vegetation.

With respect to microelement uptake, potassium fertilization was effective mainly through dry matter accumulation. K fertilization resulted in surplus uptakes of microelements till flowering, after which a decrease in Cu, Zn and Fe was observed mainly in the straw. Due to nutrient redistribution in the

Table 7

Changes in Fe content and uptake of Mv 35 winter barley during the vegetation period Örbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
					Fe, ppm				
160	120	—	1061	174	134	153	29	244	134
160	120	100	832	175	96	100	47	186	115
160	120	450	974	146	150	131	52	254	149
160	120	750	886	112	84	99	29	226	117
	$LSD_{5\%}$		343	180	136	106	—	—	—
	Mean		938	152	116	121	39	202	129
	%		100	16	12	13	4	21	14
					Fe, g/ha				
160	120	—	481	202	468	1029	95	759	854
160	120	100	384	229	379	684	188	647	835
160	120	450	511	198	729	981	193	831	1024
160	120	750	425	223	467	883	143	903	1046
	$LSD_{5\%}$		311	177	243	299	155	342	355
	Mean		450	213	511	894	155	785	940
	%		48	23	54	95	16	84	100

plant, the greater part of the Zn was to be found in the grain, Fe and Cu in the straw and Mn in equal ratios in the grain and straw.

Studying the nutrient and dry matter content of winter barley in a field experiment on a slightly humous calcareous sandy soil, the following conclusions can be drawn:

Dry matter accumulation continued until the end of the vegetation period and was the highest after shooting. K fertilization resulted in a significant surplus in the phenophases studied.

The nutrient content (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu) of winter barley was the highest at tillering, after which it decreased till harvest. The third year's after-effect of potassium fertilization (0–750 kg/ha K_2O) resulted in a significant increase in the K content and a decrease in the Ca and Mg contents.

Table 8

Changes in Mn content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
					Mn, ppm				
160	120	—	92	70	46	40	24	32	28
160	120	100	85	69	46	28	24	28	26
160	120	450	83	59	58	28	24	28	26
160	120	750	91	73	50	41	24	37	30
	$LSD_{5\%}$		18	30	27	32	—	—	—
	Mean		88	68	50	34	24	31	28
	%		100	77	57	39	27	35	32
					Mn, g/ha				
160	120	—	43	78	160	263	78	102	180
160	120	100	41	87	180	189	91	98	189
160	120	450	43	79	282	207	86	92	178
160	120	750	49	145	277	284	118	148	266
	$LSD_{5\%}$		22	29	71	179	30	58	65
	Mean		44	97	225	237	93	110	203
	%		22	48	111	117	46	54	100

The Mg content changed significantly only at shooting and tillering, but the K and Ca contents in all phenophases.

Due to K treatment macroelement uptake increased in most phenophases; Ca and Mg increased intensively in the vegetative stage and decreased in the generative stage.

Potassium fertilization resulted in surplus microelement uptake until blooming, then caused Cu, Zn and Fe to decrease partly in the grain, and partly in the straw yield.

The macroelement uptake was more intensive in the vegetative period, and that of microelements, except Mn, in the generative period (Table 11). In the vegetative period both macro- and microelement uptake exceeded the rate of dry matter accumulation many times.

Table 9

Changes in Zn content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
					Zn, ppm				
160	120	—	44	30	17	9	21	15	18
160	120	100	41	35	21	12	27	15	20
160	120	450	39	24	27	12	27	9	18
160	120	750	43	27	17	15	24	7	16
	$LSD_{5\%}$		10	17	11	10	12	—	—
	Mean		42	29	23	12	25	11	18
	%		100	69	54	29	60	26	43
					Zn, g/ha				
160	120	—	21	34	59	62	67	46	113
160	120	100	20	44	81	82	100	49	149
160	120	450	21	33	129	90	96	30	126
160	120	750	23	53	94	131	118	28	146
	$LSD_{5\%}$		11	19	28	44	30	25	39
	Mean		21	41	91	91	95	38	134
	%		16	31	68	68	72	28	100

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Table 10

Changes in Cu content and uptake of Mv 35 winter barley during the vegetation period Őrbottyán, 1978

Fertilizer applied			Tillering 17 April	Shooting 5 May	Ear emergence 23 May	Flowering 19 June	Harvest		
							Grain	Straw 15 July	Total
N	P_2O_5	K_2O							
			Cu, ppm						
160	120	—	10	10	4	5	3	11	7
160	120	100	9	10	5	6	3	12	7
160	120	450	11	6	9	3	3	5	4
160	120	750	10	7	5	3	4	3	3
	$LSD_{5\%}$		3	7	4	5	3	—	—
	Mean		10	8	6	4	3	8	5
	%		100	80	60	40	30	80	50
			Cu, g/ha						
160	120	—	5	11	14	34	10	33	43
160	120	100	5	12	20	42	12	41	53
160	120	450	6	8	44	22	11	17	28
160	120	750	5	14	28	27	18	12	30
	$LSD_{5\%}$		2	5	11	17	8	14	16
	Mean		5	11	26	31	13	26	39
	%		13	28	67	79	33	67	100

Table 11

Changes in the mean nutrient uptake during the vegetation period as a percentage of the quantity at harvest time

Nutrient	Tillering	Shooting	Ear emergence	Flowering	Harvest		
					Grain	Straw	Total
Dry matter	7	19	60	101	53	47	100
N	34	61	88	99	81	19	100
P	14	37	69	91	90	10	100
K	29	80	130	108	32	68	100
Ca	53	108	169	126	16	84	100
Mg	19	37	78	115	69	31	100
Fe	48	23	54	95	16	84	100
Mn	22	48	111	117	46	54	100
Zn	16	31	68	68	72	28	100
Cu	13	28	67	79	33	67	100

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EFFECT OF NITROGEN APPLICATION ON YIELD, LEAF NUTRIENT STATUS AND FRUIT CHEMICAL COMPOSITION OF RASPBERRY AND REDCURRANT VARIETIES

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In a pot trial with natural sand soil the nitrogen requirement of raspberry was relatively high. Nitrogen application increased the yield, cane length and the total growth of canes in the pot. 2.7–3.3% nitrogen in the leaves was considered adequate.

In the field experiment with two raspberry varieties the effect of nitrogen application on yield, vegetative growth and chemical composition of the fruit was not influenced markedly. The most pronounced correlation was between yield and fruit weight.

The adequate nitrogen level in redcurrant leaves was 2.5–2.9% in the pot experiment. The leaf N/K ratio appeared to be very important for the redcurrant. This value is optimum at about 1.0. The variety Jonkheer van Tets reacted to nitrogen application much more intensely than Red Lake.

Introduction

Small fruit production, especially the cultivation of raspberries, is very important in Hungary. Considering its annual yield of 20 000 t, Hungary is one of the most important raspberry producing countries in the world. The growing of redcurrants has also become more intensive since the introduction of more productive varieties.

At the Department of Pomology of Budapest University of Horticulture experiments have been conducted since 1968 on the nitrogen fertilization of raspberries and redcurrants. When setting up and evaluating these fertilization experiments we relied on the data of CLARK—POWERS (1945), RAMING—VANDECAVEYE (1960), NAUMANN (1961), SPIVAKOVSKIJ (1962), BOULD *et al.* (1963), LJONES (1963, 1965), SORENSEN (1965), BOULD (1968).

On the other hand, very few data were found on the fertilization of redcurrant. It was intended to augment the authenticity of the experimental results by parallel pot and field fertilization experiments.

Materials and methods

The pot nitrogen experiment on raspberry and redcurrant was conducted in large asbestos pots. These were filled with 200 kg of natural sand with only a low content of organic matter, phosphorus and potassium. The average values of the soil were as follows: pH (H_2O) 8.0, organic matter 0.7%, soluble P_2O_5 56 ppm and K_2O 88 ppm. The nutrients were introduced once a year, in March, using superphosphate and potassium sulphate.

The field nitrogen fertilization experiment on raspberry was conducted on a soil which can be characterized by the following data: pH (KCl) 5.6, organic matter 1.6%, soluble P_2O_5 97 ppm and K_2O 286 ppm. The varieties used were Malling Exploit with large fruit and Nagymarosi with small fruit.

The field nitrogen fertilization experiment on redcurrant was conducted on an alkalescent flood soil with the following characteristics: pH (H_2O) 8.0, organic matter 1.6%, soluble P_2O_5 64.5 ppm and K_2O 47.5 ppm. The test varieties were Jonkheer van Tets and Red Lake.

Fertilization was given in the form of ammonium nitrate, 50% of which was applied in October and 50% in March.

The pot experiments, as well as those in the field, were scattered in random blocks.

Measurements were made on the yield, the weight and the chemical composition of the fruit, the cane growth and the nutrient content of the leaves. This latter was analysed mainly at vintage. The foliar nitrogen content was determined by NH_3 distillation using the titrimetric method, P by the spectrophotometric method and K by the flame photometry method.

Results

Since the fundamental experiments carried out by WALLACE (1938) it has been known that raspberries are sensitive to changes in the nitrogen supply. This fact was later proved by the experiments of ECKERT (1954),

Table 1

Effect of NP supplies on yield of raspberries in pots (5-year average)

Treatments rate of nutrient, g/pot			Yield, g/pot	Fruit weight, g	Cane length, mm	N content of leaves in dry matter (%)		
N	P_2O_5	K_2O				1	2	3
—	—	15	789	1.68	915	2.06	2.21	1.69
5	—	15	1312	1.87	1083	2.50	2.55	1.96
10	—	15	1819	1.97	1328	2.66	2.74	1.99
20	—	15	1518	1.99	1789	2.79	2.86	2.07
—	5	15	787	1.66	825	2.12	2.33	1.86
5	5	15	1574	1.86	1175	2.63	2.65	1.95
10	5	15	2056	2.00	1470	2.86	2.74	2.04
20	5	15	1789	2.01	1658	2.87	2.87	2.12
—	10	15	739	1.67	859	2.13	2.33	1.87
5	10	15	1643	2.01	1217	2.56	2.63	1.94
10	10	15	1979	2.07	1530	2.89	2.79	2.03
20	10	15	2186	2.10	1912	2.87	2.95	2.20
	$SD_{5\%}$		89.93	0.06	55.83	0.111	0.055	0.049

1. at time of flowering
2. at time of harvesting
3. at end of cane growth

NAUMANN (1961), BOULD (1968), as well as by our own experiments (PAPP 1972, 1975). Since a positive N×P correlation was found in the pot experiments, it was decided that an N×P factorial fertilization pot experiment should be conducted. The major data of this experiment are to be found in Table 1.

On a sandy soil with low nutrient content, in treatments without added N fertilization the yield, the fruit weight and the length of the canes decreased significantly even when fertilized with P. On the other hand, N fertilization increased the yield even without P, but the yield could be further increased by adding phosphate. Judging by the yield, the N supply is sufficient when the N content of the leaves amounts to 2.7–3.0% at vintage. A positive correlation has been found between the N content of the leaves, the weight of the fruit, the yield, and the length of the canes.

Treatments without N resulted in the lowest total acid content and the largest total sugar content (Table 1a).

Table 2 shows the major data of N fertilization experiments in the field. The high yielding Malling Exploit and the low yielding Nagymarosi varieties showed a similar reaction to N fertilization. The yield as well as the length of the canes only increased significantly with a dosage lower than 50 kg N/ha. Further doses did not increase the yield significantly.

Table 1a

Effect of NP application on chemical composition of berries in pots (5-year average)

Treatments rate of nutrient, g/pot			Soluble solids, %	Total acid content, %	Total sugar content, %
N	P_2O_5	K_2O			
—	—	15	10.94	1.429	7.76
5	—	15	9.98	1.517	6.75
10	—	15	9.64	1.510	6.70
20	—	15	9.62	1.593	6.65
—	5	15	10.20	1.434	7.40
5	5	15	9.26	1.562	6.24
10	5	15	9.34	1.506	6.40
20	5	15	9.02	1.641	5.60
—	10	15	9.70	1.408	7.02
5	10	15	9.56	1.508	6.12
10	10	15	9.56	1.597	6.44
20	10	15	8.98	1.724	5.28

Table 2

Effect of different rates of nitrogen on raspberry yield in the field (5-year average)

Treatments	Yield, kg/pot		Fruit weight, g		Cane length, mm		N content of leaves	
	M	N	M	N	M	N	M	N
0	10.42	4.79	3.16	1.61	1878	1532	2.39	2.44
50 kg N/ha	12.15	5.84	3.45	1.71	2036	1626	2.63	2.55
100 kg N/ha	11.95	6.07	3.38	1.71	1982	1644	2.77	2.73
200 kg N/ha	11.54	5.66	3.47	1.74	2014	1682	3.08	3.07
400 kg N/ha	11.94	6.47	3.52	1.80	2030	1656	3.24	3.17
$SD_{5\%}$	1.20	0.70	0.12	0.05	79.3	61.7	0.190	0.183

M = Malling Exploit
N = Nagymarosi

The N content of the leaves increased proportionately to an increased N ratio, and attained the optimum level when 50 kg N/ha were applied. Raspberry plantations do not require more than 50–100 kg/ha N fertilizer on soils with a medium nutrient content.

In the field fertilization experiment on raspberry the data on fruit composition were similar to those obtained in pots. The N rates applied decreased the total sugar content of the berries (Table 2a).

The N supply experiments on redcurrants and raspberries were conducted in parallel. The results of the pot fertilization experiment on redcurrants are

Table 2a

Effect of different rates of nitrogen on the chemical composition of raspberry (3-year average)

Treatments	Total sugar content, %		Total acid content, %	
	M	N	M	N
Control-N_0	6.84	6.55	1.62	1.83
50 kg N/ha	5.86	6.24	1.59	1.74
100 kg N/ha	6.39	7.23	1.71	1.79
200 kg N/ha	5.92	7.04	1.67	1.70
400 kg N/ha	5.67	6.88	1.65	1.69
$SD_{5\%}$	1.453	0.755	0.109	0.224

M = Malling Exploit
N = Nagymarosi

Table 3

Effect of N fertilization on yield, shoot growth and nitrogen content of redcurrant leaves in pots

Treatment	Yield, g/pot	Shoot growth, %	N content of leaves	N/K ratio
Control-N_0	487	100.0	1.73	0.61
20 g N/pot*	654	222.7	2.84	1.70
2 kg manure/pot	793	168.2	1.98	0.77
30 g N/pot	1407	331.8	3.18	1.14
20 g N/pot	1804	295.5	3.20	1.11
10 g N/pot	1884	304.5	2.74	0.94
$SD_{5\%}$	175	10.3	0.17	

* Note: without K-application

to be found in Table 3. N fertilization substantially increased the yield of Red Lake. The results of experiment No. II show the importance of the potassium supply. The best results were obtained in the pot supplied with 10 g. The N supply to redcurrants can be taken as adequate at a level of 2.5–2.9% N content in the leaves, with a nitrogen/potassium ratio of about 1.0.

Table 4 shows the data of a field experiment on redcurrant fertilization. N fertilization did not influence the yield difference between the two varieties. N fertilization increased the yield of Jonkheer van Tets more than that of Red Lake. Jonkheer van Tets has a greater N requirement than Red Lake, both with respect to the yield and to the N content of the leaves.

Table 4

Yield and N content of redcurrant leaves in the field experiment (6-year average)

Treatment	Yield, t/ha		N content of leaves, %	
	J	R	J	R
Control-N_0	17.1	14.0	2.61	2.58
50 kg N/ha	19.6	14.7	2.88	2.75
100 kg N/ha	22.9	15.7	3.02	2.84
200 kg N/ha	24.5	15.5	3.08	2.96
$SD_{5\%}$	2.57	0.95	0.31	0.21

J = Jonkheer van Tets
R = Red Lake

The N rates applied decreased the total sugar content in the berries of the variety Jonkheer van Tets in every case. In the case of the variety Red Lake a decrease in sugar content was expressed only in berries treated with 100 kg N/ha or 200 kg N/ha (Table 4a).

Table 4a

Effect of nitrogen rates on chemical composition of redcurrant in the field experiment (5-year average)

Treatments	Soluble solids, %	Total acid content, %	Total sugar content, %
	Jonkheer van Tets		
Control-N_0	10.18	2.460	7.09
50 kg N/ha	9.57	2.503	6.83
100 kg N/ha	9.42	2.456	7.81
200 kg N/ha	9.28	2.456	6.49
	Red Lake		
Control-N_0	11.06	1.912	9.06
50 kg N/ha	10.26	1.871	9.08
100 kg N/ha	10.37	1.895	8.61
200 kg N/ha	10.47	1.948	8.57

Summing up the results of the experiments it can be stated that raspberries have a greater N requirement, while that of redcurrants is medium.

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PROLONGATION OF ETHYLENE EFFECT BY CYCLODEXTRIN COMPLEXATION OF 2-CHLOROETHANEPHOSPHONIC ACID

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2-chloroethanephosphonic acid-α-cyclodextrin inclusion complex is a water-soluble, crystalline substance from which similarly to 2-chloroethanephosphonic acid (CEPA) ethylene is released in plant cells. The release process from complex however is slower than ethylene release from the free 2-chloroethanephosphonic acid.

Using 2-chloroethanephosphonic acid-α-cyclodextrin complex the retarded ethylene release assures "prolonged ethylene effect" for the plant tissues, which results in an enhanced biological effectivity.

Introduction

Many characteristic properties of plants (flowering, ripening, abscission, etc.) can be influenced by ethylene treatment. During the storage period ethylene gas has long been used as a source of ethylene (MOLISH 1926). These days, 2-chloroethanephosphonic acid (CEPA, Ethrel, Ethephon, Rol-fruct, Camposan, etc.) provides an ethylene source releasing ethylene in aqueous solution at above pH 3.5 directly in the plant cell (ABELES 1973).

The rate of ethylene release could not be controlled in this way and it was not possible to provide a constant ethylene supply to the plants. The release of ethylene at above-optimal concentrations could provoke too rapid and not sufficiently controlled physiological responses (deterioration of horticultural products on artificial ripening). Unjustified ethylene release is wasteful and because of the high doses applied leads to undesirable air pollution.

The preparation of the 2-chloroethanephosphonic acid-α-cyclodextrin* inclusion complex has been reported by SZEJTLI *et al.* (1979) and BUDAI—SZEJTLI (1981). Complex formation led to modified ethylene release from 2-chloroethanephosphonic acid in plant tissues.

The preparation of an ethylene-α-cyclodextrin complex is described in a patent by TEIJIN (1975). The complex was utilized as an agent to provoke

* Also known as Schardinger-α-dextrin, or cyclohexaamylose. A macro ring consisting of 6 glucopyranose units which is produced from starch by the cyclodextrin-transglycosylase enzyme. The most unique characteristic feature of cyclodextrins is their ability to form inclusion complexes. Complexation (molecular encapsulation) generally modifies the physical and chemical properties of the "guest" molecule incorporated.

the rapid ripening of tomatoes. The low ethylene content (0.7 mol/cyclodextrin molecule), the circumstances of the complex-forming reaction (4.052 MPa) and the narrow field of application (the ethylene release is external, i.e. it occurs only outside the plant organism) limit the practical utilization of this substance.

Materials and methods

In the present experiments ethylene release and ethylene effect were traced by applying Rol-fruct (containing 41% 2-chloroethanephosphonic acid) in aqueous solution and 2-chloroethanephosphonic acid-α-cyclodextrin complex both in aqueous solution and in crystalline form.

Ethylene release was measured on etiolated pea germs (TÉTÉNYI 1976) by Warburg's method. Ethylene-releasing substances were tested as substrates by the usual manometric techniques based on oxygen consumption (UMBREIT *et al.* 1957). Gas volume changes due to respiration were taken into consideration using appropriate controls, thus the calculated volumes of gas evolved were a measure of ethylene release. The amount of non-decomposed 2-chloroethanephosphonic acid that remained on the surface of the primary foliage leaves of the bean plants was determined as a function of time. 2-chloroethanephosphonic acid was measured by elementary chlorine analysis (SCHULEK—SZABÓ 1973).

The ethylene effect was determined by the abscission test (TÉTÉNYI—SZEJTLI 1979) carried out on two week old bean plants (*Phaseolus vulgaris* L. cv. "Juliska"). The abscission test had to be modified for these measurements. The cut plants were put into solutions containing 2-chloroethanephosphonic acid for 24 hours and subsequently into distilled water; the time and extent of abscission were recorded. The ethylene effect measured in this way was more rapid and lower concentrations could be detected.

Results

According to the results ethylene is released from the 2-chloroethanephosphonic acid-α-cyclodextrin complex by plant tissues in a similar manner as from 2-chloroethanephosphonic acid. When etiolated pea germs were rolled in the pulverized complex and kept in sealed vials in a humid atmosphere, gas samples from the vials contained ethylene (detected by GLC). Likewise, when the crystalline complex was spread over the leaves it provoked abscission (the moisture caused by transpiration was enough to start a slow dissociation of the complex).

Figure 1 represents the time course of ethylene release followed using the manometric method. While the rate of ethylene formation is fairly constant during the first three hours when 2-chloroethanephosphonic acid is tested, the complex releases only a reduced volume of ethylene, which increases uniformly with time, not reaching the level of the former until the third hour. Ethylene release from the complex thus seems to be prolonged.

Preliminary experiments carried out under the same circumstances showed that no ethylene formation could be detected when pea germs were not present and that cyclodextrins (in low concentrations) have no effect on the intensity of respiration.

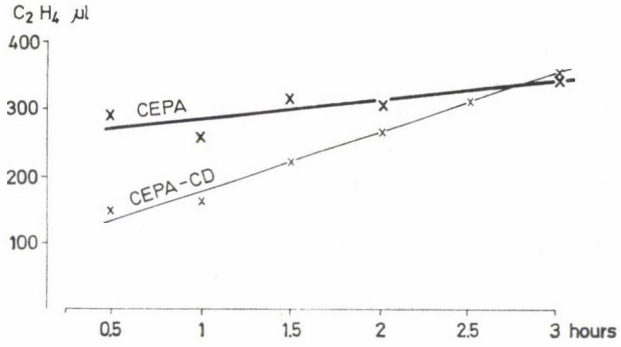

Fig. 1. Ethylene release from 2-chloroethanephosphonic acid and from 2-chloroethanephosphonic acid-α-cyclodextrin complex by 48 hour old pea germs (Warburg's method)

The amount of 2-chloroethanephosphonic acid sprayed onto the leaves of bean plants and washed off at different times is represented in Fig. 2. Six hours after treatment only 10% of the free 2-chloroethanephosphonic acid was detectable, while 40% of that incorporated into the complex was retained. There is practically no trace of 2-chloroethanephosphonic acid detectable on the leaves in the 12th hour, but the complex still retained 20% of the original amount of 2-chloroethanephosphonic acid sprayed onto the leaves.

These experimental results prove that both the absorption of 2-chloroethanephosphonic acid and the release of ethylene start retardedly in the case of the 2-chloroethanephosphonic acid-α-cyclodextrin complex compared to free 2-chloroethanephosphonic acid. The retarded action can be explained by the addition of the complex dissociation process to the two processes determining

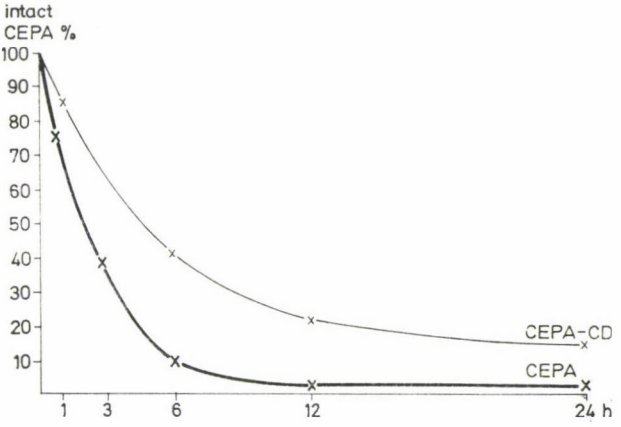

Fig. 2. Adsorbed but not decomposed 2-chloroethanephosphonic acid from free and complexed forms on the surface of bean leaves

the "ethylene effect" up till now: diffusion into the cell and ethylene release determined by the pH of the cell.

Whether this prolonged ethylene effect due to retarded ethylene release provokes a more active physiological response compared to free 2-chloroethanephosphonic acid was further investigated.

The defoliating effect of 2-chloroethanephosphonic acid and its α-cyclodextrin complex were traced by the abscission test. The results in Table 1 show that when applying equal doses the complex provokes more rapid abscission. These results seem to support the theory of the effectiveness of the prolonged ethylene effect.

Table 1

Abscission effect of free and complexed 2-chloroethanephosphonic acid (CEPA) in the bean test

Treatment	Concentration	Defoliation, %		
		18 h	24 h	48 h
α-cyclodextrin	17.54 μg/ml*	0	0	0
CEPA	5×10^{-5} M	0	33	50
CEPA-α CD complex	5×10^{-5} M	17	67	83

* 17.54 μg/ml corresponds to the α-cyclodextrin concentration of the complex

This physiological observation is being tested for horticultural application (TÉTÉNYI 1981). These experimental results and the price of the complex-forming cyclodextrin when produced on an industrial scale will determine whether the 2-chloroethanephosphonic acid-α-cyclodextrin complex will be introduced into agricultural practice.

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THE EFFECT OF (±)-THREO-1-PHENYL-2-NITRO-1,3-DIACETOXY-PROPANE ON THE INTENSITY OF RESPIRATION IN SOME HIGHER PLANTS AND *FUSARIUM OXYSPORUM*

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The effect of a new fungicide on the intensity of respiration in some higher plants (wheat, bean and cucumber) and in *Fusarium oxysporum* was investigated. This compound, (±)-threo-1-phenyl-2-nitro-1,3-diacetoxypropane (PNDP), a member of the phenyl-nitropropane group, was developed in the Plant Protection Laboratory of the EGYT-Pharmacochemical Works. The compound was found to decrease the respiration of *Fusarium* at a concentration two orders of magnitude lower than that required for higher plants. The inhibition of respiration seems to be not a primary but a secondary effect in the case of both higher plants and *Fusarium* sp.

Introduction

Besides the new biological prevention methods, traditional pesticides also have great importance in the present practice of plant protection. Among this wide range of chemically different compounds, a less known family, the phenyl-nitropropane derivatives, could also play a significant role in plant protection. Some biologically active nitro derivatives occur naturally (ECKSTEIN 1965) and synthetic members of this group are mentioned in the literature as bactericide agents (REHN—NOLTE 1979). A new compound in the phenyl-nitropropane group, (±)-threo-1-phenyl-2-nitro-1,3-diacetoxypropane (PNDP), has recently been developed in the Plant Protection Laboratory of EGYT-Pharmacochemical Works. This compound possesses a strong fungicidal effect and is intended for use in plant protection practice. Before it can be utilized for this purpose, it is necessary to investigate its effect on the development and metabolic pathways of higher plants and to evaluate its phytotoxicity.

Materials and methods

Beans (*Phaseolus vulgaris*, Juliska), wheat (*Triticum aestivum*, F 481 Kompolt) and cucumber (*Cucumis sativus*, Budai fürtös) seedlings were grown in Knop medium for three days without illumination. The seedlings were illuminated from the 4th day on and 10, 50 or 100 ppm of PNDP were added to the media. The solution was changed every day. The intensity of light was adjusted to 10 000 lux and the temperature was maintained at 24 °C. *Fusarium*

oxysporum EGYT T-11 aerated liquid cultures were grown in 1 l Czapek medium, as described by SURICO—GRANITI (1977), to which 0.025 to 0.1 ppm of PNDP was added. Flasks were inoculated with 1 ml 10^8/l conidia and the cultures were kept at 24 °C in diffuse light for eight days.

For the determination of intensity of respiration, 1 g fresh weight of roots from 7 day old seedlings or *Fusarium oxysporum* mycelia was used. The measurement of pO_2 and the calculation of μl O_2 consumption was carried out according to Warburg's method (SZALAI—FRENYÓ 1972).

Results and discussion

The μl O_2 consumption of 1 g fresh weight of root/h was calculated from data measured over a period of 15 minutes and is summarized in Table 1. The changes in μl O_2 consumption during a 20 minute measuring period can be seen in Figs 1, 2 and 3. The same parameters were measured for *Fusarium oxysporum*, but the amount of PNDP was two orders of magnitude smaller than before, i.e. 0.025, 0.05 and 0.1 ppm. The results were calculated in the same way and are shown in Table 1 and Fig. 4.

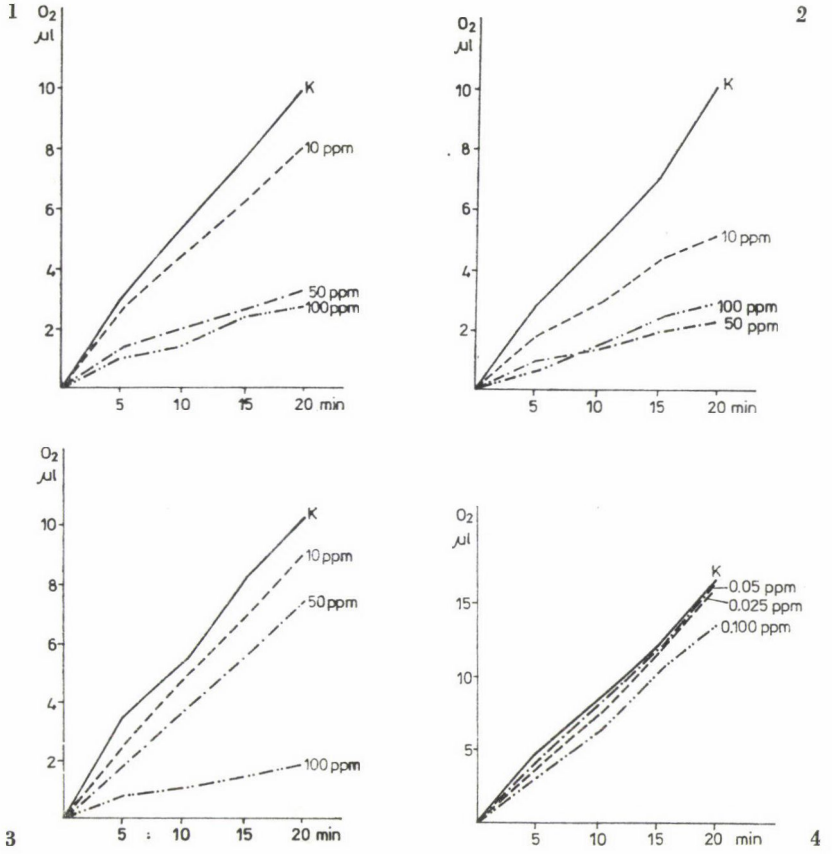
Table 1

The μl O_2 consumption of 1 g fresh weight of root/hour and the intensity of respiration as a percentage of the control in beans, wheat and cucumber treated with 10, 50 or 100 ppm of PNDP and in Fusarium oxysporum treated with 0.025, 0.05 and 0.1 ppm of PNDP

	Beans		Wheat		Cucumber			*Fusarium oxysporum*	
Treatments	O_2 consumption μl/g fresh weight/h	intensity of resp. as a % of control	O_2 consumption μl/g fresh weight/h	intensity of resp. as a % of control	O_2 consumption μl/g fresh weight/h	intensity of resp. as a % of control	Treatments	O_2 consumption μl/g fresh weight/h	intensity of resp. as a % of control
Control	33.2	100	30.4	100	28.8	100	Control	48.72	100
10 ppm	27.6	83.2	24.8	81.6	17.6	61.1	0.025 ppm	48.72	100
50 ppm	22.4	74.3	10.4	34.2	8.0	27.7	0.05 ppm	48.77	100.1
100 ppm	5.6	16.8	9.6	31.6	9.8	34.0	0.1 ppm	41.36	84.4

The immediate effect of exogenous PNDP on the respiration of control plants was also measured. These data are summarized in Table 2 and in Figs 5, 6, 7 and 8.

According to the results, pre-treatment with PNDP at fairly high concentrations seems to have an effect on the respiration of higher plants, and cucumber proved to be the most sensitive towards the compound. Exogenous PNDP decreases the respiration intensity to a much lower extent than endogenous PNDP, suggesting that its effect is indirect rather than direct and may be the consequence of its influence on other metabolic pathways. From the results it can be concluded that PNDP affects the respiration of higher plants at a concentration two orders of magnitude higher than that required for

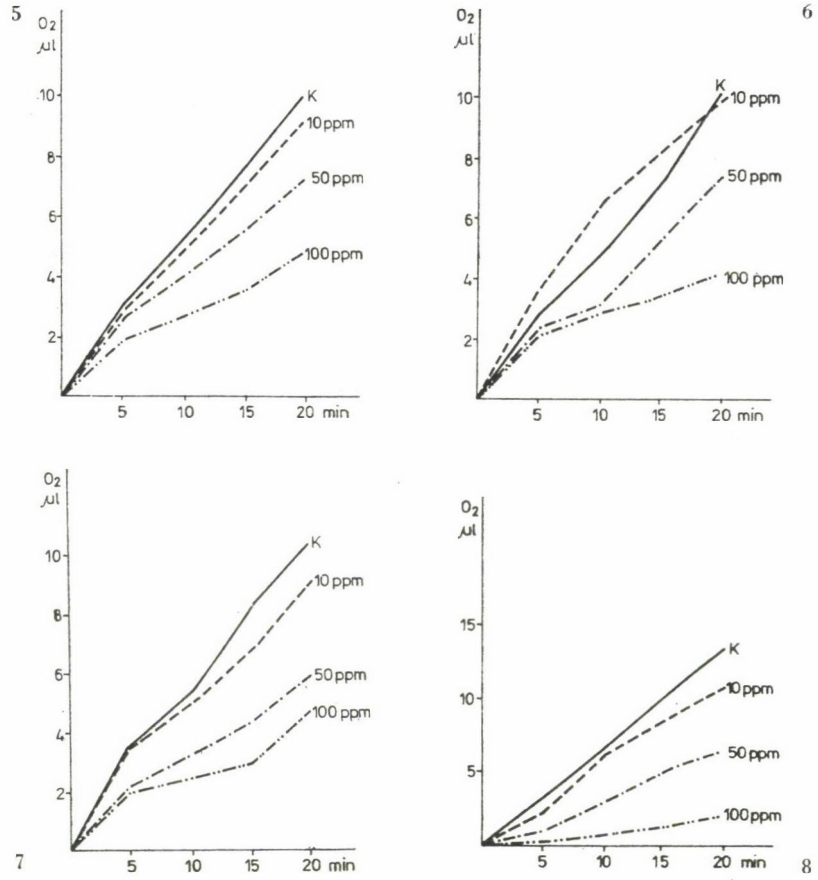


Figs 1–4. O_2 consumption of 1 g fresh weight of roots of 8 day old wheat (Fig. 1), cucumber (Fig. 2), beans (Fig. 3) and Fusarium sp. (Fig. 4) pre-treated with different concentrations of PNDP

Table 2

The µl O_2 consumption of 1 g fresh weight of root/hour and the intensity of respiration as a percentage of the control in beans, wheat and cucumber and in Fusarium oxysporum exogenously treated with 10, 50 and 100 ppm of PNDP

Treatments	Beans		Wheat		Cucumber		*Fusarium oxysporum*	
	O_2 consumption µl/g fresh weight/h	intensity of resp. as a % of control	O_2 consumption µl/g fresh weight/h	intensity of resp. as a % of control	O_2 consumption µl/g fresh weight/h	intensity of resp. as a % of control	O_2 consumption µl/g fresh weight/h	intensity of resp. as a % of control
Control	33.2	100	30.4	100	28.8	100	40.42	100
10 ppm	27.0	83.1	28.0	92.1	32.4	112.0	33.04	81.7
50 ppm	17.4	52.4	22.0	72.4	13.8	47.9	19.86	49.1
100 ppm	12.0	36.1	14.2	46.7	13.8	47.9	4.77	11.8



Figs 5–8. O_2 consumption of 1 g fresh weight of roots of 8 day old wheat (Fig. 5), cucumber (Fig. 6), beans (Fig. 7) and Fusarium sp. (Fig. 8) as the immediate effect of exogenous PNDP

Fusarium oxysporum and the difference seems to be high enough to permit its use as a plant protective fungicide. Other experiments in progress in the laboratory indicate that the inhibition of the Hill reaction and CO_2 fixation of higher plants is also a secondary effect. PNDP probably directly influences nucleic acid or protein synthesis.

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EFFECT OF DIETARY ZINC CONCENTRATION ON WEIGHT GAIN, FEED UTILIZATION, AND ORGANIC Zn LEVELS IN BROILER CHICKENS

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The effect of different dietary zinc supplies was studied in 4 experimental groups of broilers (A, B, C and D), over a period of 7 weeks. All birds received the same basal diet with an average zinc content of 73 ppm, but the dietary Zn level was increased by supplementation to 114, 294 and 530 ppm for the birds of groups B, C and D. At the birds received 294 and 530 ppm zinc in the diet (groups C and D) was significantly less weight gain than at the groups A and B, without notable decrease in feed consumption. It was concluded that the about 70 ppm zinc concentration, is sufficient for an optimal weight gain and feed conversion rate while higher dietary levels of Zn depress rather than enhance weight gain. The maximum hepatic zinc level (39.9 ppm) found was still less than the maximum permissible level (40 ppm) in Hungary. The zinc content of the thigh muscle did not exceed 15.1 ppm, i.e. it was less than half of the maximum permissible level, even in the group given the highest dietary zinc supply. The Fe- and, especially the Al-content of the femoral bone tended to decrease with rising zinc supplementation.

Introduction

The essential trace element significance of zinc was recognized in 1934 (Todd *et al.* 1934). Since then, various functions of zinc, including its role in the intermediary metabolism of animals (Prasad 1966, Sas 1977, Simon 1978, Underwood 1977) have been described. At present literary reports concerned with zinc are almost as numerous as those dealing with iron. In the present paper the effects of different dietary supplies of zinc on the weight gain, feed utilization and organic Zn levels of broiler chickens were studied in order to obtain information on the optimal growth promoting concentration, and on the possible cumulative effect of 8–10 times elevated dietary levels on certain organs (liver, muscles, bones).

It was shown earlier (Tölgyesi 1969) that although the soils of Hungary and the fodder plants grown on them contain considerable amounts of biologically active zinc (soils on average 45 ppm; cereals 25–40, soya bean meal 70, animal protein diets 65–90 mg/kg), part of the zinc requirement of broiler chickens produced under large management systems is still supplied in the form of premixes composed of inorganic zinc salts.

Many authors have studied the metabolism and various physiological effects of zinc in poultry.

It was shown that, in this species, too, zinc absorption depends not only on the physical properties and chemical composition of the feed, but also on the nature of the zinc compound supplied, as well as on the actual condition of the digestive system, and the quality of the chymus (PRÉCOUD *et al.* 1975). Up to 4 weeks of age, zinc supplied in the form of carbonate salt at 20 ppm dietary level had an optimal influence on feed utilization and weight gain; similar levels of zinc oxide and zinc sulphate were somewhat less effective (ROBERTSON—SCHAIBLE 1960). Zinc absorption tended to increase in birds on a high carbohydrate diet (LANDES 1975), and tended to decrease at 0.8% Ca and a high Cu concentration in the feed (LIKUSKI—FORBES 1965). Dietary Cd and Pb also depressed the intestinal absorption and functions of zinc (CHEN *et al.* 1974). The quantitative relations of intestinal zinc absorption influence the serum (and plasma) levels of Zn. About 80–90% of the blood Zn content is protein- (albumin) bound. The average serum Zn level of adult chickens was assessed as 2.5 ppm (SAS 1977), while the average plasma level proved to be 15% less (HARTLAND—BRUBAKK 1973).

Zinc was demonstrable in all the organs of poultry, but at different concentrations. The incorporation of zinc into muscles is slow, and the quantity incorporated varies with the type of muscle. Dark red muscles contain more zinc (30–60 mg/kg) than those of light red colour (CASSENS *et al.* 1967).

The hepatic level of zinc is high, owing to its participation in the hepatic metabolism. The zinc content of the mammalian liver was found to range between 141 and 245 mg/kg dry matter (LEIBETSEDER *et al.* 1971).

Zinc is abundantly present in the skin and its horny appendages. Zinc depletion accounts for feathering disturbances in poultry (SUNDE 1972).

High concentrations of zinc have been demonstrated in certain parts of the central nervous system (CNS), but its functional role in these structures is still not fully understood. In mammals, the cerebral cortex contains 80 mg/kg and the hypothalamus 800 mg/kg Zn (SMEYERS-VERBEKE *et al.* 1974). Other authors (LEIBETSEDER *et al.* 1971) assessed the average zinc content of the brain as only 12.9 mg/kg.

Zinc is indispensable for normal bone development. Its deficiency gives rise to characteristic changes in the cartilaginous and bone tissues of mammals and poultry (WESTMORELAND—HOEKSTRA 1969). The average zinc content of the long bones is 40–80 mg/kg in fresh bone tissue.

Apart from the above organs, considerable amounts of zinc have been detected in erythrocytes, the pancreas, the reproductive organs, and in semen. Zinc plays an important functional role in the activity of various enzymes, the endocrinic system, biological membranes and the immune system.

Part of the organic zinc is loosely bonded, easily released and rapidly eliminated, while part is firmly bonded, and its mobilization takes a considerable time. It stays in the liver 10–12 days, in heart muscle 160, in fat tissues

1045, in bones 1193, in certain cerebro-spinal segments 1430–1506 days (DONALDSON *et al.* 1973), and in the myoglobin of muscles even longer (JÖRGENSEN—WEGGER 1976).

Materials and methods

A total of 208 broiler hybrid cockerels were used in the experiment. They were selected from a flock of 300 birds at one day old, by culling the ± variants, and were 14 days old at the beginning of the experiment. They were divided by body weight into 4 equal groups (A, B, C and D), each consisting of 52 cockerels. In each group, the birds were caged by 13, in batteries at different levels of the rack, under controlled climatic conditions, as follows:

I	II	III	IV
A_1	D_2	C_3	B_4
B_1	A_2	D_3	C_4
C_1	B_2	A_3	D_4
D_1	C_2	B_3	A_4

The compositions of the chick starter and the premix fed to the birds during the 2-week preliminary period between hatching and the start of the experiment, are shown in Tables 1 and 2. The average zinc content of the starter-premix was assessed by several measurements as 172 ppm.

The feeding experiment lasted 5 weeks in groups A, B and C, and 7 weeks in group D. All birds received the same broiler diet (Table 3), but the zinc content of the premix was different for each group.

The composition of premix B_{212} was the same as that shown in Table 2, except that 12.5 g Rigecoccin was added for the prevention of coccidiosis, and technical grade zinc oxide was mixed into it at quantities of 0.0, 5.2, 24.9 and 49.8 for groups A, B, C and D, respectively.

Table 1

Composition of the chick starter

Component	%
Maize meal	66.8
Soybean meal (48% C.P.)	22.0
Fish meal (70% C.P.)	8.0
Limestone (calcium carbonate)	1.2
Hostaphos (Ca, P, Mg-supplement)	1.0
Premix B_{211} (without Zn)	1.0

Table 2

Composition of the B_{211} premix (without zinc-bacitracin and zinc oxide, in 1000 g of the premix)

Vitamin A, 500 000 IU/g	3.00 g (1 500 000 IU)
Vitamin D_2, 200 000 IU/g	1.00 g (200 000 IU)
Vitamin E, 25%	3.00 g (750 IU)
Vitamin K_3	0.20 g
Vitamin B_1	0.2 g
Vitamin B_2	0.4 g
Vitamin B_6	0.4 g
Vitamin B_{12}, 1 mg/g	4.0 g
Biotin, 1%	0.2 g
Folic acid	0.03 g
Calcium-D-pantothenate	1.20 g
Nicotinic acid (tech. grade)	3.00 g
Potassium iodide, 1% trituration	3.00 g (0.02 g I)
Manganese sulphate, monohydrate	12.43 g (4.0 g Mn)
Copper sulphate, pentahydrate	1.93 g (500 mg Cu)
Sodium selenite, 1% trituration	2.27 g (6.67 mg Se)
Iron sulphate, heptahydrate	20.00 g (2.67 g Fe)
Cholin chloride, 50%	140.00 g
EMQ; 66.0% (antioxidant)	10.00 g
Methionine	10.00 g
Flavomycin, 2%	10.00 g
Cereal meal	ad 1000.00 g

Table 3

Composition of basal diet

Component	%	Calculated* Zn content (mg)
Maize meal	68.2	10.9
Soybean meal	24.7	13.8
Fish meal, 70%	3.0	2.6
Lime	1.5	7.5
Hostaphos	1.3	6.5
NaCl	0.3	1.5
Premix B_{212}	1.0	—
		Total: 42.8 mg

* Based on Tölgyesi's non-published data (1979)

Thus the diets of the four groups differed only in respect of zinc supplement:

	Zinc supplement (ppm)	Total dietary Zn content (ppm)
Group A:	—	62– 84 (73)
Group B:	50	116–112 (114)
Group C:	200	292–296 (294)
Group D:	400	520–540 (530)

It follows that the cockerels of group A received no zinc supplement, while the diets for groups B, C and D were supplemented with 50, 200 and 400 ppm zinc, respectively. Since the average zinc content of the basal diet was 73 ppm; the total dietary zinc supply was 73, 114, 294 and 530 ppm, respectively, for birds in groups A, B, C and D.

The experimental diets were generally fed for 5 weeks (until 7 weeks of age) in all groups except D, in which experimental feeding lasted 7 weeks (until 9 weeks of age). The birds were then returned to the basal diet, which contained 73 ppm zinc.

Feed and drinking water were made available ad libitum throughout the period of the experiment.

The body weights of the birds were determined at 2, 3 and 7 weeks of age, the Zn and Fe contents of blood plasma and certain organs (thigh muscle, liver, brain, femoral bone) at several sampling intervals, and the Zn, Fe and Al contents of the femoral bone at weeks 3 and 5, in group D at weeks 6 and 7, of the experiment. Organ samples were secured from 3–4 birds in all groups at each sampling interval.

The trace elements were determined in 1 ml blood plasma, 1–5 g samples of soft organs, and in the whole femoral bone, after appropriate wet maceration, by gravimetry, colorimetry, or atomic absorption spectrophotometry (Perkin—Elmer 5000 atomic absorption spectrophotometer) according to the procedures stipulated by the AOAC (ANONYMOUS 1975). The trace element content found was always related to crude (non-delipidised) wet weight.

Results

The body weight at 7 weeks of age and the feed efficiency are shown in Table 4.

Table 4

Mean body weights and feed conversion rates of the birds at the end of the feeding experiment (49 day old birds)

Group of cockerels	No.	Mean body weight (g)	Feed conversion (kg/kg live weight)
A	46	1.428 ± 39.5	2.52
B	45	1.417 ± 38.0	2.47
C	45	1.380 ± 33.8	2.54
D	46	1.357 ± 32.4	2.50

Table 5 shows the initial Zn and Fe contents of the thigh muscle and the liver, determined before the beginning of the experimental diet. The mean

Zn contents measured in blood plasma, liver, thigh muscle, brain and bones at weeks 3 and 5 (in group D at weeks 6 and 7) of zinc supplementation are shown in Table 6.

Table 5

Initial Zn and Fe contents of muscles and liver at 2 weeks of age

No. of birds	Zn, mg/kg*		Fe, mg/kg*	
	in muscle	in liver	in muscle	in liver
4	7.2–18.0 (15.6)	36.0–48.0 (43.0)	53.6–66.3 (60.0)	33.8–112.8 (73.3)

* Related to kg wet tissue

Table 6

Mean plasma and organ levels of Zn at weeks 3, 5, 6 and 7 of the experiment (5, 7, 8 and 9 week old birds)*

Time of sampling	Groups	Blood plasma	Liver	Muscle	Brain	Bone
3rd week	A	—	26.5	13.6	11.8	91.7
	B	—	25.2	14.7	11.4	91.2
	C	—	29.1	15.0	11.5	97.2
	D	—	29.3	16.0	11.3	92.2
5th week	A	3.1	33.9	17.2	9.5	85.0
	B	2.9	34.8	16.9	13.9	88.3
	C	2.5	39.9	14.1	11.8	84.2
	D	1.6	32.4	15.1	11.4	89.5
6th week	A	—				
	B	—				
	C	—				
	D	2.6	29.4	14.1	11.8	79.7
7th week	A	—				
	B	—				
	C	—				
	D	4.3	31.7	14.3	12.9	68.5

* mg/kg wet tissue

The Fe contents determined at the above intervals in the liver, thigh muscle and femoral bone of Zn-supplemented cockerels are presented in Table 7.

Table 7

Mean Fe contents in liver, thigh muscle* and femoral bone at weeks 3, 5, 6 and 7 of the experiment (5, 7, 8 and 9 week old birds)*

Time of sampling	Groups	Liver	Muscle	Bone
3rd week	A	100.1	72.5	107.6
	B	108.9	62.7	108.1
	C	177.6	69.8	96.1
	D	100.5	85.6	96.2
5th week	A	137.9	73.8	89.1
	B	160.7	59.9	89.7
	C	138.2	56.8	99.2
	D	171.6	64.2	97.8
6th week	A			
	B			
	C			
	D	109.6	52.0	83.7
7th week	A			
	B			
	C			
	D	144.2	72.2	72.2

* mg/kg wet tissue

Table 8 shows the mean concentrations of 3 trace elements (Zn, Fe, Al) in femoral bones at the above sampling intervals.

Discussion

The growth rate and health of the cockerels was good even throughout the period of the experiment, and in *no* case were *clinical symptoms* observed. An analysis of inter-group differences in body weight for statistical significance showed that zinc supplementation at 50 ppm (group B) had no influence on weight gain compared to a plain diet (group A), but zinc supplements of 200 ppm (group D) depressed the weight gain significantly ($p < 0.01$).

Inter-group differences in feed conversion were not significant ($p < 0.1$) in any relation, indicating that the approx. 70 ppm dietary level of zinc, generally present in the broiler chicken rearing feeds available nowadays in Hungary, is sufficient for optimal weight gain as well as optimal feed utilization. This could be due to the enhancement of zinc levels (contents) in maize

Table 8

Zn, Fe and Al content of femoral bone at weeks 3, 5, 6 and 7 of the experiment (5, 7, 8 and 9 week old birds)

Time of sampling	Groups	Zn	Fe	Al
		mg/kg		
3rd week	A	92.0	107.6	12.2
	B	91.0	108.1	6.4
	C	97.0	96.1	4.9
	D	92.0	96.2	5.7
5th week	A	85.0	89.1	3.7
	B	88.3	89.7	3.6
	C	84.0	99.2	4.1
	D	90.0	97.8	3.7
6th week	A			
	B			
	C			
	D	75.0	83.7	3.7
7th week	A			
	B			
	C			
	D	69.0	72.2	3.4

(+50–60%) and soybean meal (+10–12%). Higher levels of Zn not only increase the costs of such diets to no avail, but concentrations of above 50 ppm depress weight gain, and, to a certain degree, also feed utilization, and the excreted Zn excess pollutes the environment of the birds.

No unequivocal correlation was demonstrable between the Zn contents of the blood plasma and the diet. The highest plasma Zn level (4.3 ppm) was observed in group (D), which was given the highest Zn supplement. In the other groups the mean plasma Zn level varied between 1.6 and 3.1 ppm, i.e. slightly above the range indicated by HARTLAND—BRUBAKK (1973).

The mean hepatic Zn content was 25.2–39.9 ppm; it increased slightly over the basal level during the first 5 weeks of Zn-supplementation, and was highest (39.9 ppm) in group (C), supplemented at 200 ppm level of zinc; in this group it reached the maximum tolerated level (40 ppm) established in the food hygiene regulations valid in Hungary.

The Zn content of the thigh muscle ranged between 13.6 and 17.2 ppm, and its mean value did not rise above 15.1 ppm even at the highest level (530 ppm) of dietary zinc supply (group D). This concentration was con-

siderably lower than the highest range (30–60 ppm) hitherto observed (CASSENS *et al.* 1967), and less than half of the maximum tolerated level (40 ppm). It follows that the organism itself—by the reduction of absorption—prevents excessive incorporation of zinc by the muscles, which means that no accumulation of food hygienic significance is likely to occur in chicken meat.

The brain samples examined contained 9.5 to 13.9 ppm zinc. No unequivocal correlation was found with the level of dietary supply. The celebral Zn concentrations measured in the present study were generally lower than the usually very high values (80–100 ppm) reported in the literature, but corresponded roughly with the mean concentration (12.9 ppm) found by LEIBETSEDER and co-workers (1971) in pig brain.

The mean hepatic Fe content generally increased as the Zn supplement was raised, from an average of 73.3 ppm (basal level) to usually above 100 ppm. It reached a peak (1816 ppm) in the group given the highest (530 ppm) dietary zinc supply, after 5 weeks of the experimental diet. The Fe content of the skeletal muscles also increased slightly (by a maximum of 25.6 ppm) over the basal level (60 ppm) as a result of Zn supplementation. It follows that dietary Zn supplementation gave rise to a considerable increase of Fe in the liver, and a slight increase of Fe in the muscles.

The Zn content of the femoral bone increased by a few ppms parallel to, the progression of zinc supplementation, and reached a maximum (90 ppm) in group (D), which was given the highest supply. The concentrations of Fe and Al tended to decrease in the femoral bone as the level of zinc supplementation was raised.

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VARIA

CLUSTER ANALYSIS BASED ON FACTOR ANALYSIS, APPLIED TO DESIGNATE ECOLOGICAL REGIONS OF MAIZE PRODUCTION

While examining the complex connection of farm-scale plant production data it often occurs that ecological factors overlap the effect of the agrotechnical factors (ÁNGYÁN 1979, 1980, LŐRINCZ *et al.* 1979, MENYHÉRT *et al.* 1980). Consequently, in most cases the "ecological homogenization" of the observed units (farms, fields, etc.) is unavoidable. The term "habitat conditions", however, is a complex concept, in the formation of which a large number of variables take part, differing in significance and being more or less interrelated. Consequently, their multi-dimensional clustering goes beyond the models of classical two-way classification, and can only be solved through the utilization of multivariate statistical methods.

The problems arising can be summed up as follows: the great number of variables, their different dimensions and orders of magnitude, divergent importance in the formation of the dependent variable, and the fact that these variables are not independent (multi-collinearity).

Therefore, the following tasks have to be accomplished during group formation:

1. *The selection of variables* describing the units can be made more or less objective on the basis of correlations and previous professional knowledge.

2. *Standardization of variables.* The distance, similarity or dissimilarity between the observed units consists of the distances measurable along the individual variables; consequently, the group formation is sensitive to the value range and to the units in which the variables are measured.

If the aim is for each character to prevail in an equal proportion, the original data must be standardized.

From among the possibilities available for solution (MÓDOS 1980, ORLÓCI 1967, PODANI 1980, SVÁB 1979) the transformation of variables into variables with "o" expected value and "s" standard deviation has been chosen.

That is:

$$x'_{ih} = (x_{ih} - \bar{x}_i) \frac{1}{s_i}$$

where: x'_{ih} = is the standardized value of the ith variable for the hth observation unit;
x_{ih} = is the original value of the ith variable for the hth observation unit;
$\bar{x}_i$ = is the average of the ith variable;
s_i = is the standard deviation of the ith variable.

3. *The reduction and weighting of the variables* in the present model are accomplished *by factor analysis.* This method determines "background" variables, which are independent from one another, have no dimensions, and which concentrate the observed variables according to the scale of their weight and importance. In the case of further calculations factors whose eigenvalue is higher than 1 ($\lambda > 1$) have been used. The method and its utilization are widely discussed in the literature (GETHER—SIMON 1972, HARMAN 1960, HOLZINGER—HARMAN 1941, LAWLOY—MAXWELL 1963, PAPP 1978, 1980, SVÁB 1979, TRYON 1959, ÜBERLA 1971, WEBER 1974). However, the variables observed not only play different roles in the correlation system (factor loading), but also have different effects on the response variable (average yield of maize) (preference weight). There have been attempts to determine objectively the preference weights (KINDLER—PAPP 1977). When determining the factor values, this has been resolved in the present model by multiplying the standardized values of the original variables not only with the eigenvector values (SVÁB 1979), but also with the coefficient of determination between the response variable (average yield of maize) and the variables observed, namely:

$$C'_{jh} = \sum_{j=1}^{q} u_{ij} r^2_{yi} x'_{jh}$$

where: C'_{jh} = is the value of the jth factor for the hth observation unit;
u_{ij} = is the eigenvector-coefficient of the ith variable in the jth factor;
r^2_{yi} = is the coefficient of determination between the ith variable and the response variable;
q = is the number of $\lambda > 1$ factors.

4. *Multivariate group formation.* If the required high proportion of the total variance of the group-forming variables can be explained by 1 or 2 factors, the classification of observed units can also be accomplished graphically (BERNÁT—ENYEDI 1977, JONES—GOLDSMITH 1968, STEINER 1965, SVÁB 1979, ZHUKOVSKAYA—KARPOV 1967).

But if the system can be characterized suitably by several background variables, the group formation can only be accomplished by cluster analysis. Cluster analysis has two main phases:

(a) *The choice of the comparative function* suitable for the problem (FÜSTÖS 1977, 1978, FÜSTÖS *et al.* 1977, MÓDOS 1980, PODANI 1980). The largest group of comparative functions (more than 100 types of mathematical formulae) is composed of the similarity and dissimilarity coefficients (CZEKANOWSKI 1909, GOWER 1971, JACCARD 1901, SOKAL—MICHER 1958, WISHART 1969). The other major group of comparative functions is represented by the distance functions (PODANI 1980).

In the course of factor analysis factors independent from one another have been determined; consequently, a special case of the Minkowski metrics, the Euclidean distance calculation, has been used. The distance between two optional (k, l) observation units in the rectangular factor-space can be calculated by the following formula:

$$d^2_{kl} = \sum_{j=1}^{q} (C'_{jk} - C'_{jl})^2$$

where: d_{kl} = is the distance between the k and l observation units;

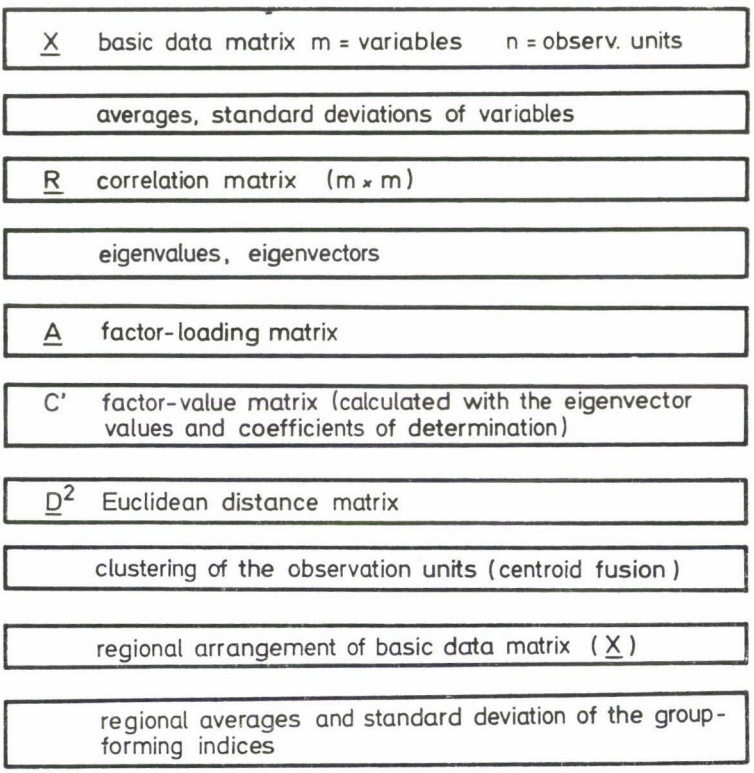

Fig. 1. Construction of the group-forming model

Table 1

Correlation and determination coefficients between maize yields and climatic elements

	Designation	Month	r	r^2
1	Temperature (°C)	IV	0.465*	0.216
2		V	0.264*	0.070
3		VI	0.416*	0.173
4		VII	0.437*	0.191
5		VIII	0.468*	0.219
6		IX	0.406*	0.165
7		X	0.386*	0.149
8		X–III	0.058	0.003
9	Precipitation (mm)	IV	0.114	0.013
10		V	0.101	0.010
11		VI	0.183	0.034
12		VII	−0.192	0.037
13		VIII	0.058	0.003
14		IX	0.108	0.012
15		IV–IX	0.091	0.008
16		X–XI	0.083	0.007
17	Sunshine (hours)	IV	−0.322*	0.104
18		V	−0.070	0.005
19		VI	0.170	0.029
20		VII	0.367*	0.135
21		VIII	0.175	0.031
22		IX	0.343*	0.118
23		IV–IX	0.258*	0.067
24	Minim. temper. (°C)	V	0.409*	0.167
25		IX	0.036	0.001

$r_{5\%} = 0.215^*$ $n = 83$

C'_{jk} = is the value of the jth factor for the kth observation unit;
C'_{jl} = is the value of the jth factor for the lth observation unit.

(b) The choice of a suitable fusion algorithm and the accomplishment of the clustering. There are 15 algorithms available for accomplishing clustering (PODANI 1980), from among which the "Centroid method" has been chosen, which can be used to analyse the distance matrix, calculated in Euclidean space. In each step this method combines those clusters, the centroids of which are the nearest to one another.

The clustering subroutine was made by F. SZIDOROVSZKY, scientific researcher at the University of Horticulture in Budapest.

Table 2

Factor-loading matrix for climatic elements

Designation	Month	Factor-loadings (a_{ij})				IV $\sum_{j=I} a_{ij}^2$
		I	II	III	IV	
°C	IV	0.879*	−0.092	−0.250	0.084	0.851
	V	0.410	−0.029	−0.102	0.464*	0.395
	VI	0.799*	−0.218	−0.125	0.289	0.785
	VII	0.879*	−0.113	−0.291	0.092	0.879
	VIII	0.900*	−0.215	−0.236	0.001	0.912
	IX	0.866*	−0.082	−0.307	−0.218	0.899
	X	0.788*	−0.226	−0.210	−0.034	0.717
mm	X–III	0.585*	0.377	0.432	0.080	0.677
	IV	0.290	0.159	0.276	0.262	0.254
	V	0.286	0.495*	−0.298	0.282	0.496
	VI	0.531*	0.692*	0.043	0.009	0.763
	VII	−0.161	0.757*	−0.053	−0.005	0.602
	VIII	0.247	0.733*	0.061	−0.159	0.627
	IX	0.243	0.518*	0.430	0.381	0.657
	IV–IX	0.390	0.875*	0.084	−0.041	0.927
	X–IX	0.530*	0.769*	0.266	−0.054	0.946
hours	IV	−0.594*	−0.412	0.207	−0.170	0.595
	V	−0.224	−0.609*	0.227	−0.127	0.497
	VI	0.573*	−0.353	0.487*	−0.269	0.762
	VII	0.869*	−0.230	0.377	−0.011	0.950
	VIII	0.598*	−0.408	0.483*	−0.153	0.781
	IX	0.744*	−0.211	0.266	−0.091	0.678
	IV–IX	0.661*	−0.459	0.518*	−0.157	0.941
°C min.	V	−0.737*	−0.224	−0.404	−0.215	0.802
	IX	0.192	0.115	0.496*	−0.667*	0.741
λ		9.312	5.007	2.425	1.359	18.103
$\Sigma\,\lambda$ (%)		37.248	57.276	66.976	72.412	

$a_{ij\,5\%} = \sqrt{r_{5\%}} = 0.464^*$

During the evaluation the steps accepted were those where the standard deviation of the original variables in most groups, observed within the group, was below 50% of the original standard deviation. There is no doubt that at this point the model is rather subjective and needs further improvement. [It is conceivable that by incorporating multiple discrimination analysis (MDA) into the model, the group formation can be stopped where the intergroup difference is significant.]

Fig. 2. Climatic regions for maize production

With the assistance of the KSZE Plant Production System, and the participation of the Department of Farming and Plant Production, the Computer Centre and the Department of Water Management of the Gödöllő University of Agricultural Sciences the coefficients of correlation (r) and determination (r^2) between the yield and climatic elements (Table 1) and the factor-loading matrix of the climatic elements (Table 2) were ascertained on the basis of 25 climatic characteristics and the maize yield of 83 farms, applying the average values of a 10-year period. After this the factor value matrix was established. From this the Euclidean distance matrix was calculated, and after carrying out clustering the 83 farms were arranged into 5 regions (Fig. 2).

The difference between the yields of regions having the best (No. 2) and the most unfavourable (No. 4) climatic conditions may be put at about 2.0 tons, while the difference between the production costs is around 900 Ft (Table 3).

Table 3

The average value of climatic elements in the climatic regions

	Designation	Month	Climatic regions					Total
			1	2	3	4	5	
1	Temperature (%)	IV	9.83	10.43	9.52	9.27	9.94	9.80
2		V	15.27	15.65	14.49	14.69	15.50	15.14
3		VI	18.49	18.94	18.33	17.87	18.62	18.84
4		VII	19.50	20.22	19.38	19.22	19.80	19.62
5		VIII	19.11	19.92	18.99	18.68	19.28	19.22
6		IX	15.49	16.23	15.22	15.18	15.60	15.54
7		X	9.83	10.46	9.75	9.54	8.94	9.90
8	Precipitation (mm)	X–III	273.25	262.95	235.96	216.74	254.96	249.30
9		IV	46.41	44.02	44.46	42.27	46.01	44.80
10		V	59.76	65.87	55.36	69.90	67.30	60.80
11		VI	86.83	83.83	65.86	75.34	91.25	77.00
12		VII	68.48	59.30	57.74	72.92	85.39	62.90
13		VIII	75.23	65.96	56.11	66.32	69.37	64.20
14		IX	57.32	43.81	43.88	41.47	54.41	46.70
15		IV–IX	392.28	363.63	322.02	357.58	419.27	354.90
16		X–IX	666.72	625.24	558.86	574.19	679.77	604.60
17	Sunshine (hours)	IV	180.56	179.80	190.73	184.17	185.76	184.70
18		V	236.17	237.06	242.06	233.42	242.49	237.90
19		VI	247.01	254.21	248.16	228.46	241.72	246.90
20		VII	264.19	275.21	252.48	225.63	251.57	257.50
21		VIII	242.82	248.15	244.14	223.74	244.67	242.70
22		IX	184.55	190.10	176.43	167.52	175.81	180.40
23		IV–IX	1354.52	1382.02	1352.36	1258.71	1342.01	1348.10
24	Minim. temp. (°C)	V	2.04	3.44	1.90	1.78	2.39	2.30
25		IX	2.91	4.05	3.22	3.59	4.42	3.45
Number of farms			15	18	33	12	5	83
Average yield of maize (t/h)			5.69	6.11	4.95	4.07	4.95	5.31
Production costs (Ft/t)			1870.59	1683.00	2109.33	2579.78	2079.09	1896.88

The region having the most favourable climatic conditions (No. 2) included 148 fields from among the 655 observed, so as an example the clustering of fields was also accomplished on the basis of 22 field configuration and soil testing indices, in the manner described above (Tables 4, 5). The 148 fields were thus arranged into 7 groups (Table 6).

The difference between the yields of the most favourable (No. 2.2) and most unfavourable (No. 2.3) groups can be put at 2.34 tons/ha.

Within the field groups, which have homogeneous habitat conditions, the difference in yield is caused unequivocally by the different varieties (hybrids) and agrotechnics. In order to illustrate this, the results of regression analysis on the stock number and yields will be presented (Fig. 3). The hybrid Pi MSC 3780 was produced on 180 fields out of a total of 655.

The connection between stock number and yield can be characterized by a parabola, but if the analysis is accomplished in a contracted way, the connection is very vague and not significant, but when it is carried out according to the ecological regions, this connection is strong and significant.

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Table 4

Correlation and determination coefficients between maize yields and soil characteristics

Designation	r	r^2
1 Area (ha)	−0.191*	0.037
2 Slope	−0.202*	0.041
3 Disposition	0.371*	0.138
4 Erosion	−0.273*	0.075
5 Constraint	0.112	0.013
6 Underground water-level	−0.294*	0.086
7 $CaCO_3$ (%)	−0.015	0.000
8 pH	0.081	0.007
9 Humus	0.193*	0.037
10 P_2O_5 (mg%)	−0.018	0.000
11 K_2O (mg%)	0.197	0.039
12 NO_3–NO_2 (mg%)	0.085	0.007
13 Mg (mg%)	0.206*	0.042
14 Na (mg%)	−0.434*	0.188
15 Zn (mg%)	−0.072	0.005
16 Cu (mg%)	0.111	0.012
17 Mn (mg%)	−0.115	0.013
18 Total salt (%)	−0.201*	0.040
19 P_2O_5 (%)	0.076	0.006
20 K_2O (%)	−0.208*	0.043
21 NO_3–NO_2 (%)	0.139	0.019
22 Value in gold crowns	0.465*	0.216

$r_{5\%} = 0.185^*$ $n = 148$

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Table 5

Factor-loading matrix for soil characteristics

Designation	Factor-loadings (a_{ij})					$\sum_{j=I}^{V} a_{ij}^2$
	I	II	III	IV	V	
1 Area (ha)	*0.555**	0.177	−0.239	−0.042	0.133	0.416
2 Slope	−0.257	*0.688**	0.320	−0.265	−0.177	0.742
3 Disposition	0.112	*−0.660**	−0.349	0.280	0.128	0.665
4 Erosion	−0.369	*0.560**	0.312	−0.375	−0.167	0.716
5 Constraint	0.316	*−0.518**	−0.253	−0.290	−0.096	0.499
6 Underground water-level	*−0.493**	*0.626**	−0.275	0.099	0.099	0.730
7 $CaCO_3$ (%)	*−0.481**	−0.120	−0.191	0.148	−0.316	0.404
8 pH	*−0.538**	−0.131	*−0.481**	−0.127	−0.232	0.608
9 Humus (%)	−0.145	*−0.630**	−0.210	−0.130	−0.037	0.480
10 P_2O_5 (mg%)	*−0.594**	−0.197	−0.074	*0.589**	−0.159	0.769
11 K_2O (mg%)	−0.162	0.373	−0.123	*0.577**	*0.465**	0.730
12 NO_3–NO_2 (mg%)	−0.076	−0.406	*0.786**	0.196	0.090	0.835
13 Mg (mg%)	*0.507**	*−0.604*	−0.009	−0.151	−0.108	0.656
14 Na (mg%)	0.531*	0.328	−0.382	0.184	−0.316	0.669
15 Zn (mg%)	0.111	−0.123	0.188	*0.452**	0.058	0.271
16 Cu (mg%)	*0.551**	−0.270	0.121	−0.048	0.301	0.484
17 Mn (mg%)	*0.564**	0.125	*0.482**	0.343	0.042	0.686
18 Total salt (%)	*0.454**	−0.092	*0.454**	0.371	−0.197	0.597
19 P_2O_5 (%)	*−0.805**	−0.102	−0.066	0.410	−0.096	0.840
20 K_2O (%)	−0.413	*0.559**	−0.043	0.027	*0.570**	0.811
21 NO_3–NO_2 (%)	−0.227	−0.205	*0.805**	−0.115	−0.049	0.757
22 Value in gold crowns	−0.327	*−0.584**	0.056	−0.080	0.390	0.610
λ	4.151	3.975	2.760	1.838	1.253	13.977
$\Sigma\,\lambda$ (%)	18.866	36.934	49.482	57.836	63.532	63.532

$a_{ij\,5\%} = \sqrt{r_{5\%}} = 0.430^*$ $\quad n = 148$

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Table 6

The average value of soil characteristics in field groups for climatic region No. 2

Designation	Field groups of climatic region No. 2							Total
	1	2	3	4	5	6	7	
1 Area (ha)	77.5	68.5	116.5	25.0	17.0	31.0	33.0	73.3
2 Slope	0.6	0.5	0.0	0.0	1.0	3.0	2.0	0.5
3 Disposition	2.8	3.5	4.0	4.0	2.5	0.5	0.0	3.0
4 Erosion	0.6	0.4	0.0	0.0	0.0	3.0	3.0	0.4
5 Constraint	38.0	42.1	53.2	40.0	30.5	36.0	39.0	39.6
6 Underground water-level	10.0	3.5	4.4	0.5	3.0	7.0	4.0	7.4
7 $CaCO_3$ (%)	5.2	2.1	8.6	0.9	22.0	2.9	4.2	4.2
8 pH	7.1	6.9	7.9	7.0	7.4	7.2	7.4	7.1
9 Humus	2.2	2.6	3.7	2.7	1.6	1.7	2.0	2.3
10 P_2O_5 (mg%)	19.4	19.1	13.4	46.0	39.5	5.0	60.0	19.9
11 K_2O (mg%)	22.3	17.8	12.0	32.0	12.5	9.0	21.0	20.3
12 NO_3–NO_2 (mg%)	1.7	3.6	3.3	2.5	4.2	4.8	2.1	2.5
13 Mg (mg%)	23.7	40.1	38.4	9.6	6.6	15.6	21.0	29.4
14 Na (mg%)	10.4	5.4	13.1	0.4	0.9	1.2	4.1	8.6
15 Zn (mg%)	0.2	0.3	0.2	0.7	0.3	0.1	0.1	0.2
16 Cu (mg%)	0.3	0.5	0.4	0.3	0.2	0.1	0.1	0.4
17 Mn (mg%)	8.1	10.6	3.8	10.0	7.7	6.1	3.7	8.9
18 Total salt (C%)	0.02	0.04	0.05	0.00	0.02	0.01	0.01	0.03
19 P_2O_5 (mg%)	22.3	19.2	11.0	45.3	51.0	12.0	53.5	21.7
20 K_2O (mg%)	26.9	18.6	9.5	31.5	18.0	21.0	18.8	23.4
21 NO_3–NO_2 (C%)	2.1	3.7	2.7	2.5	6.5	11.0	1.9	2.8
22 Value in gold crowns	23.3	29.5	22.6	30.0	21.0	23.0	30.2	25.6
Number of fields	29	49	12	4	2	1	1	148
Average yield of maize (t/ha)	6.7	7.3	5.0	7.2	5.6	5.7	6.9	6.9

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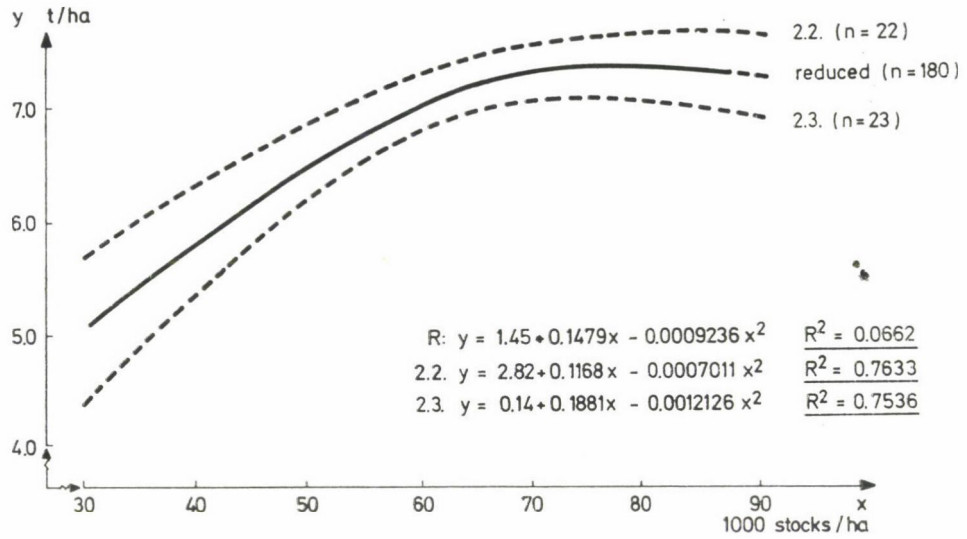

Fig. 3. Relationship between the yields of the Pi 3780 hybrid maize and the number of stocks in the complete jumble of data, in the 2.2 and 2.3 ecological regions

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GENETIC ANALYSIS OF FODDER YIELD IN OATS

Among the non-legumes, oats constitute the only popular fodder crop for livestock in northern India. They are grown during the winter season either as a monoculture or in a mixture with Berseem (*Trifolium alexandrinum* Linn.) and are fed to the animals as fresh fodder or sometimes as hay. Very little work has been done in the past to improve the existing cultivars of oats with respect to fodder yield. A knowledge of the combining abilities of the parents and the mode of inheritance of the character needing improvement is essential for formulating an effective breeding programme. The present study was therefore undertaken to gather genetic information on fodder yield in oats.

The experimental material comprised ten diverse varieties of oats, namely Sierra, Kent, V7, Appler, Australian, Kanota, Montreena, IPC, Co59 and Algerian (Co59 belonged to *Avena byzantina* C. Koch, while the rest belonged to *A. sativa* Linn.). All the parents and their 45 non-reciprocal crosses were grown during the winter season of 1975–76 in a randomised block design with three replications at Punjab Agricultural University, Ludhiana. The single row plot was grown at a distance of 22 cm and the seeds were spaced 15 cm apart. Fodder yield was recorded on five randomly chosen plants for each treatment. GRIFFING's (1954) method II and model I were used for working out the combining abilities, while graphical analysis (ALLARD 1956) and components of variance analysis (HAYMAN 1954) were used to work out the mode of inheritance of fodder yield in oats.

Analysis of variance (Table 1) showed the presence of a sufficient amount of variability among the parents, as well as among the crosses. The combining ability analysis (Table 2) revealed that both general and specific combining ability variances were highly significant. This indicated the importance of both additive and non-additive gene effects for fodder yield in oats. Similar results regarding fodder yield have been reported by ARORA *et al.* (1974). PARODA *et al.* (1974), however, reported the presence of non-additive gene effects over additive gene effects for this character.

Table 1

Analysis of variance for the experimental design

Source	df	Mean squares
		Fodder yield
Blocks	2	9050.16
Treatments	54	9972.47**
Error	108	3206.80

** P = 0.01

Table 2

Analysis of variance for combining ability in oats

Source	df	Mean squares
		Fodder yield
GCA	9	4963.94**
SCA	45	3167.16**
Error	108	1068.93

** P = 0.01

The estimates of general combining ability effects are given in Table 3. Appler, the highest yielder, was found to be the best general combiner for fodder yield. A low non-significant value of correlation coefficient (rs = +0.18) between the general combining ability effects of the parents and their mean performances showed that for fodder yield mean performance was not an indication of the general combining ability of the parents involved. This was contradictory to the findings of ARORA *et al.* (1974). The specific combining ability effects and estimates of heterosis over both the better parent and the best check (Appler) are given in Table 4. Heterosis over the best check (Appler) has been given because in a practical breeding programme it is the performance of the hybrid over the best check that ultimately decides its utility. Crosses showing high SCA effects showed high percentage heterosis over the best check. For example, Kanota × Algerian, Appler × Algerian, Appler × IPC, Sierra × Kanota, Sierra × V7, Australian × Kanota, Appler × Australian, Kanota × Co59, Appler × Kanota and IPC × Algerian, which had high SCA effects, showed more than 60% heterosis over the best check, and either both or at least one parent was a good general combiner. The range of percentage heterosis of the crosses over the better parent was −8.80 to 190.20%, while the heterosis over the best check was −28.00 to 86.60%. The number of crosses showing more than 60% heterosis over the better parent was twenty-six and over the best check only eleven. This showed the utility of working out the heterosis over the best check in a practical breeding programme for selecting promising crosses.

The graphical analysis (Fig. 1) revealed the presence of complete dominance with genic interactions for fodder yield, because the regression line passed through the origin and deviated significantly from unit slope (b = 0.0649 ± 0.1319). The relative position of the array points in the graph showed that Kanota (6) and Algerian (10), which had low yields,

Table 3

Estimates of general combining ability effects in oats

Parents	Forage yield
1. Sierra	− 3.45 (133.19)
2. Kent	−15.44 (125.94)
3. V7	2.43 (128.42)
4. Appler	26.02* (168.58)
5. Australian	− 5.84 (143.65)
6. Kanota	17.95 (108.42)
7. Montreena	−45.69** (90.51)
8. IPC	9.09 (130.84)
9. Co59	− 1.21 (120.52)
10. Algerian	16.14 (107.73)
SEgi ±	8.95

* P = 0.05. ** P = 0.01
Values in parentheses are parental means

Table 4

Mean performance, SCA effects and heterosis of crosses for fodder yield in oats

Crosses		Mean performance	SCA effects	Heterosis (%)	
				Better parent	Best check (Appler)
1		2	3	4	5
Sierra	× Kent	238.69	49.95	79.20	41.50
	× V7	284.46	77.84	113.50	68.70
	× Appler	219.23	−10.98	30.00	30.00
	× Australian	131.37	−67.27	−8.70	−22.20
	× Kanota	285.03	62.88	114.00	69.00
	× Montreena	150.61	− 7.89	13.00	−10.60
	× IPC	218.70	5.42	64.20	29.70
	× Co59	200.80	− 2.18	50.70	19.10
	× Algerian	247.66	27.33	85.90	46.90
Kent	× V7	218.85	24.22	70.40	29.80
	× Appler	196.47	−21.74	16.50	16.50
	× Australian	153.20	−33.15	6.60	− 9.10
	× Kanota	191.08	−29.07	51.70	13.30
	× Montreena	146.92	0.42	16.60	−12.80
	× IPC	243.07	41.78	85.70	44.10
	× Co59	252.25	61.27	100.20	49.60
	× Algerian	206.25	− 2.09	63.70	22.30
V7	× Appler	269.75	33.65	60.00	60.00
	× Australian	207.22	2.99	44.20	22.90
	× Kanota	205.21	−22.82	59.70	21.70
	× Montreena	174.15	9.77	35.60	3.30
	× IPC	233.76	14.59	78.60	38.60
	× Co59	210.98	2.12	64.20	25.10
	× Algerian	252.04	25.82	96.20	49.50
Appler	× Australian	280.83	53.01	66.50	66.50
	× Kanota	278.02	26.40	64.90	64.90
	× Montreena	168.18	−19.81	−0.20	− 0.20
	× IPC	305.10	62.34	80.90	80.90
	× Co59	233.28	0.83	38.30	38.30
	× Algerian	308.30	53.49	82.80	82.80
Australian	× Kanota	281.66	61.91	96.00	67.00
	× Montreena	223.43	67.33	55.50	32.50
	× IPC	195.74	−15.15	36.20	16.10
	× Co59	236.60	36.02	64.70	40.30
	× Algerian	216.87	− 1.07	50.90	28.60
Kanota	× Montreena	207.49	27.58	91.30	23.00
	× IPC	241.20	6.57	84.30	43.00
	× Co59	278.37	53.99	130.90	65.10
	× Algerian	314.64	72.90	190.20	86.60
Montreena	× IPC	162.52	− 8.52	24.20	− 3.50
	× Co59	121.24	−39.49	0.50	−28.00
	× Algerian	200.18	22.09	85.80	18.70
IPC	× Co59	254.99	39.47	94.80	51.20
	× Algerian	276.44	43.56	111.20	63.90
Co59	× Algerian	239.94	17.37	99.00	42.30

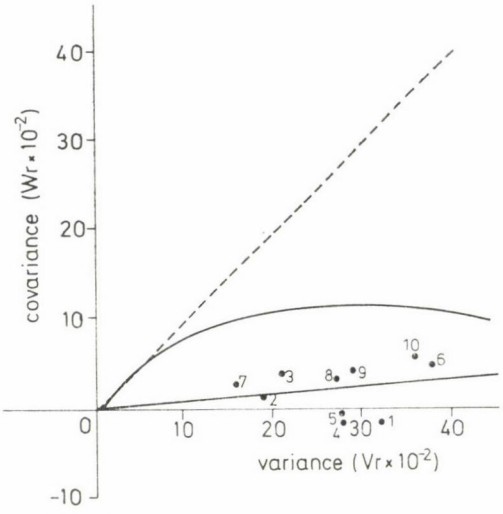

Fig. 1. Vr-Wr graph of fodder yield in oats

possessed maximum concentration of recessive alleles, while Sierra (1), Appler (4) and Australian (5), which had high yield, possessed almost an equal frequency of dominant and recessive alleles. The scatter of the array points along the regression line revealed the presence of genetic diversity for fodder yield among the parents and was the possible reason for high heterosis in the crosses.

Components of variance analysis (Table 5) revealed the significance of the dominant component (H_1), while the additive component (D) was negative and non-significant. This

Table 5

Estimates of genetic components of variance in oats

Character	D	H_1	H_2	F	E	$\overline{uv}$	Correlation between Wri + Vri and Yri
Forage yield	−609.22	7983.92**	6676.86**	1698.38	1068.93**	0.20	0.088
SE±	534.06	1136.81	966.16	1232.25	161.25		

** P = 0.01

might have been due to the effect of the environment because the environmental component (E) was highly significant. The high value of $\overline{uv}$ and the non-significant value of F, a measure of the relative frequency of dominant and recessive alleles, suggested a symmetrical distribution of dominant and recessive genes for this character. The non-significant value of the correlation between the order of dominance of the parents (Wri + Vri) and the parental measurement Yri suggested that some dominant genes were acting in a desirable direction and others in an undesirable direction.

The major points which emerged from the above study were that both additive and non-additive gene effects with complete dominance were important for fodder yield in oats. Heterosis over the best check provided a better criterion for selecting crosses than heterosis over the better parent. The best three crosses in order were Kanota × Algerian, Appler × Algerian and Appler × IPC. Both the parents in each of these crosses were good general combiners and the extent of heterosis for green fodder yield was of the order of 86.60, 82.80 and 80.90% respectively over the best check. Some other crosses showing more than 60% heterosis

over the best check were Sierra × Kanota, Sierra × V7, Australian × Kanota, Appler × Australian, Kanota × Co59, Appler × Kanota and IPC × Algerian. Since these crosses also involved at least one parent which was a good general combiner for fodder yield, in order to accumulate more additive genetic variance for green fodder yield, inter se mating in the F_2 generation of these crosses should be made, either by using the biparental approach or by using the North Carolina mating design (COMSTOCK—ROBINSON 1952).

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THE VOLATILE OIL SECRETORY SYSTEM OF TARRAGON (ARTEMISIA DRACUNCULUS L.) ROOTS

Although tarragon (*Artemisia dracunculus* L.) is principally regarded as a spice (GESSNER 1953), in certain cases it is also used as a drug (BERGER 1954). Since it is the aboveground parts (herba) of the plant that are used, it is mainly these that have been studied. The histological description of the drug was carried out by OBERMEYER (1937), together with the description of other herbs belonging to the genus Artemisia. This description is still cited (METCALF—CHALK 1950, ROSENTHAL 1954). Obermeyer did not examine the histological structure of the root.

Few data are available on the utilization of the roots. GILDEMEISTER—HOFFMANN (1961) mention having once distilled some brown oil from them. The chemical processing of the roots has recently begun; GREGER—BOHLMANN (1979), for example, produced 8-hydroxycapillarine from them.

For many years the plant has been examined from various aspects at the Research Institute for Medicinal Plants (TÉTÉNYI 1963, 1970; STIEBER *et al.* 1975, LASSÁNYI—STIEBER 1976). The present paper gives an account of histological observations on the root, with particular emphasis on the volatile oil secretory system, and includes analyses by means of thin layer chromatography.

Description of the plant material. The tarragon (*Artemisia dracunculus* L.) used in the experiment was a variety of the "French" type named "Zöldzamat", bred at the Research Institute for Medicinal Plants and state registered in 1976 (ANONYMOUS 1980). This is a high yielding variety produced by clone selection; it is homogeneous as to its phenotype and composition, and has a high volatile oil and estragole content (STIEBER *et al.* 1975).

Half the plant material used in the experiment consisted of plants propagated in March 1979 by division, while the other half consisted of plants propagated in June 1979 by planting rooted shoots. Thus, the plants examined were not of the same age. Samples were taken at two-week intervals from the spring of 1980 until the first cutting (26th March–2nd June), and the major morphological features were recorded. In spite of the cool spring and late initiation of vegetation the rainy weather resulted in intensive shoot formation in April and a fast rate of growth in the course of the spring; thus, by the time of the first cutting

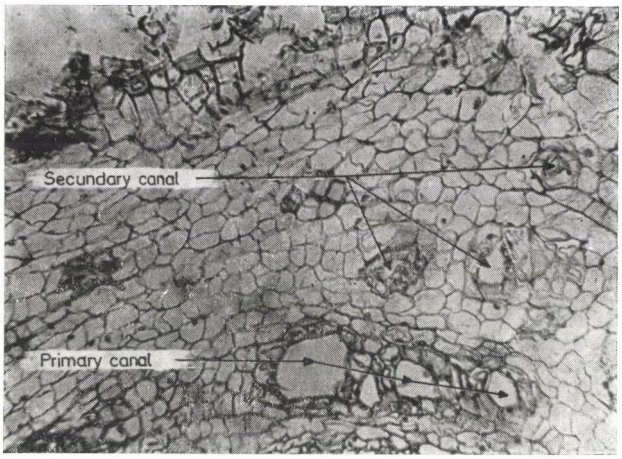

Fig. 1. Cross-section of the root cortex. Primary and secondary canals (excretion cavities) (×100)

the plants had reached a height of 69–95 cm and had developed 5–20 shoots per plant, depending on age.

Histological examination. For the histological examinations the plants were fixed in a mixture of formalin, acetic acid and alcohol (FAA), and after tertiary butyl alcohol dehydration were embedded in paraffin. A 13 μm thick section series was then prepared in the usual way (JOHANSEN 1940). The sections were stained with a 0.20% solution of toluidine blue; 2% solutions of potassium iodide and ferricyanide mixed in equal parts were used as chelating agent (ROMHÁNYI 1968). The mounting medium was Canada balsam. The microscope examinations were carried out with a Reichert Zetopan research microscope.

Examination by thin layer chromatography. Plants were dug up, rinsed in water and mopped with filter paper. The histological structure of the root was checked in a freehand section by microscope. The material (young root, thick root, shoots of both younger and older plants) was cut up roughly with a scalpel and 0.1–0.2 g of each was filled into a TAS-cartridge (STAHL 1969). Using the TAS technique, the volatile components of the material were applied

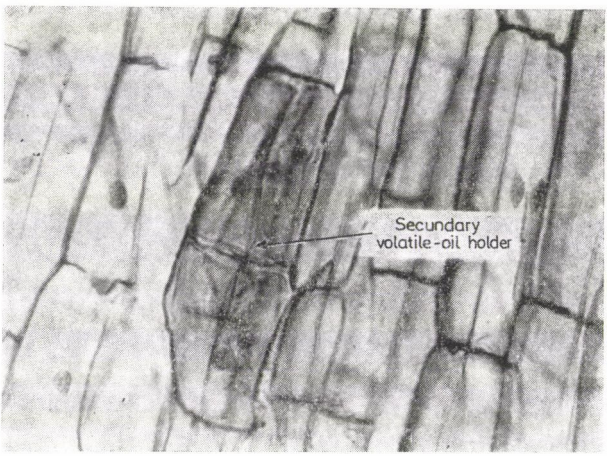

Fig. 2. Development of secondary excretion cavities in the cortex (longitudinal section, ×252)

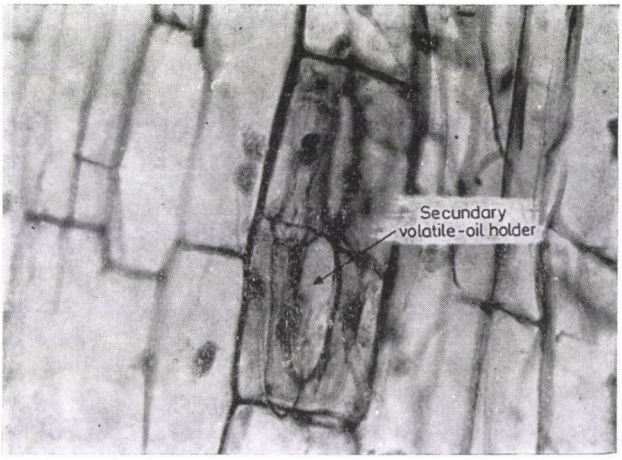

Fig. 3. Development of secondary excretion cavities in the cortex (longitudinal section, ×252)

at 140 °C to a Kieselgel G (Woelm) layer prepared in the usual way (STAHL 1967). Prior to being used the TLC plates were activated at 110 °C. Elution was carried out in a saturated chromatographic tank. A mixture of benzene—ethyl acetate (96 : 4) was used as solvent. The length of run was 12 cm. As developer reagent vanillin—sulphuric acid was employed. The TLC plates were evaluated after being heated for 15 minutes at 110 °C.

Plants propagated in a vegetative manner have only an adventitious root system. Young roots are covered externally by a rhizodermis, with a few rows of parenchyma underlying it; the cortex is closed by an endodermis with Casparian dots. Where the endodermis borders on the cortex large volatile oil canals are found which extend through the stem (rhizome). The pericycle is one-layered, enclosing the three simple phloem and xylem bundles (triarch). In the course of development the rhizodermis is replaced by a lignified exodermis, then paracambium is formed from the outer cells of the cortex. Old roots are covered by a periderm. The endodermis is transformed into secondary endodermis; the cells all round become suberised. Through the activity of the pericambium new lateral roots are formed, and the cambium also adds new elements both to the xylem and to the phloem; the centre of the old

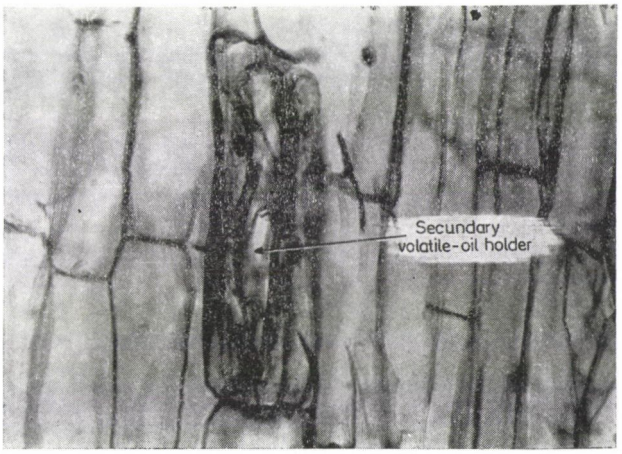

Fig. 4. Development of secondary excretion cavities in the cortex (longitudinal section, ×252)

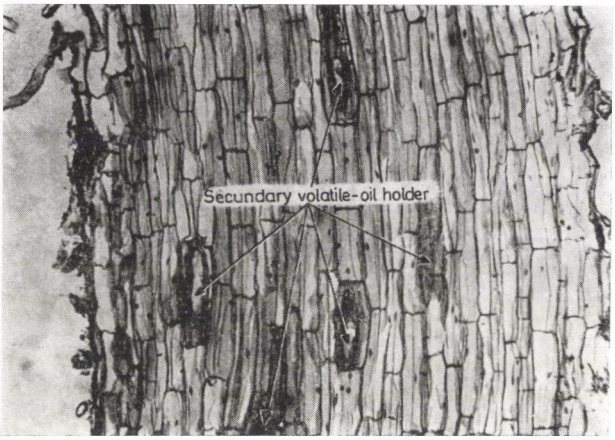

Fig. 5. Development of secondary excretion cavities in the cortex (longitudinal section, ×100)

root is finally replaced by contiguous lignified elements surrounded by phloem which has also become contiguous. The first phloem elements can be seen as fibres near the pericycle. Besides the processes outlined above changes also take place in the volatile oil secretory system. Apart from the primary volatile oil canals excretion cavities develop in two other ways. These do not extend into the stem. In the course of the thickening of the root certain cells of the cortex resume their meristematic activity; when looked at in cross-section they first divide into 4 cells, then each of them into a further two cells (Fig. 1). Their walls become suberised, and a schizogenous intercellular space is formed between them (Figs 2–4). Similar processes are described by HILLSON (1979) as taking place in the leaf of Senecio rowleyannus, a plant belonging to the same family. In tarragon roots the cells which resume a meristematic character are not always in the same plane. In the course of development the process continues, and a canal is formed from the previously independent cells (Figs 5–6). Secretion also starts, and the substances, known as volatile oil, which are pressed through the cell-wall, gather in the intercellular space. Observations show that the plasm of secretory and accessory cells differs from that of the surrounding cells (Fig. 7). The cells in the third type of volatile

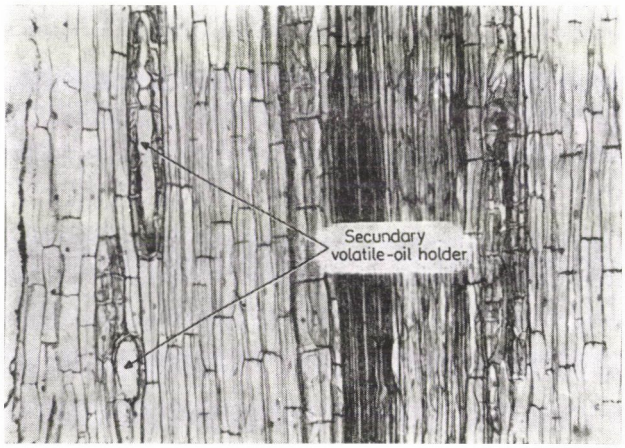

Fig. 6. Separately developed excretion cavities fusing in the cortex (longitudinal section ×100)

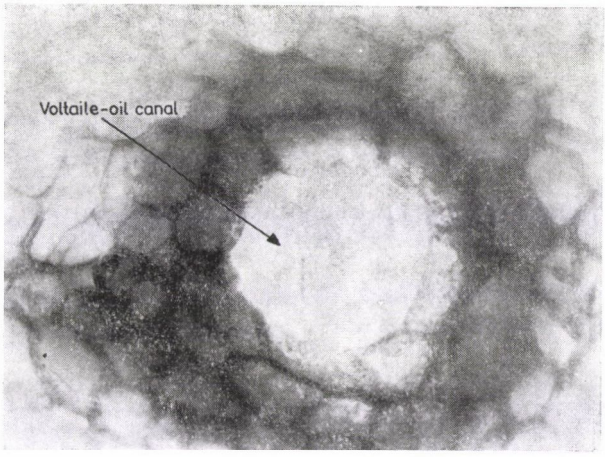

Fig. 7. The large volatile oil canal near the endodermis (cross-section, ×252)

oil canal are produced through the activity of the cambium, together with the sieve-tube companion cell groups (Fig. 8).

Since the composition of the volatile oil in the two types of volatile oil system (glandular hair and volatile oil canal) studied earlier in the tarragon leaf was not the same (LASSÁNYI—STIEBER 1976), it was assumed that the secretions found in the volatile oil canals (excretion cavities) in the root, which had again developed in different ways, would not have the same composition either. When applying general volatile oil reagents such as Sudan III and De Chatellier reagent (JORK—KRAUS 1975) the secretions in all canals excretion cavities turned red, unlike for example the prochamazulene in the inflorescence of *Matricaria chamomilla* L. (LASSÁNYI *et al.* 1978). Thus, canals (excretion cavities) of different origin could not be separated histochemically, nor in the manner in which this was done in the case of the leaf. Thin layer chromatography was therefore employed in an attempt to find indirect proof. It was assumed that the volatile oil in young roots, in which only the canals next to the endodermis had developed, was similar to that in the shoots. When examining the serial sections it was seen that canals in the stem (rhizome) extend into the root, i.e. they are con-

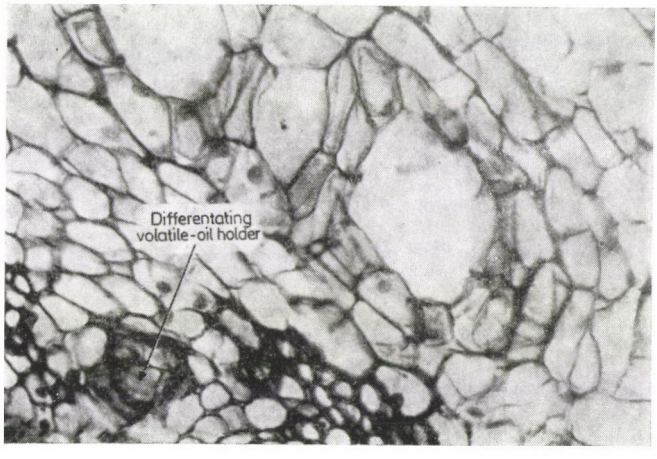

Fig. 8. Differentiation of an excretion cavity from the cambium (cross-section, ×252)

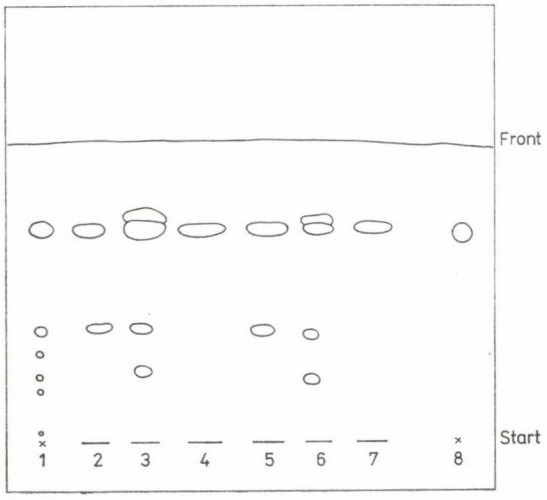

Fig. 9. Examination of thermomicro-distillates of tarragon by one dimension thin layer chromatography. Younger plant: 1. tarragon oil (standard), 2. thin root, 3. thick root, 4. shoot. Older plant: 5. thin root, 6. thick root, 7. shoot, 8. methyl chavicole (standard)

nected with each other. Simultaneously with the development of the secondary systems a change may take place in the composition of the volatile oil. To confirm this, parts of young and old plants which had similar histological structures were compared. For the purposes of comparison, estragole (methyl chavicole), the main component of the volatile oil in the above-ground parts, and a benzene diluted solution of the oil obtained from the shoot by steam distillation, were used. A single characteristic chromatogram is presented here (Fig. 9). As seen in the figure, the chromatogram of the very young root resembles that of the shoot, containing estragole as the main component, while in thicker roots with secondary excretion cavities there is more than one component. (These substances will be dealt with in another paper.)

The investigations seem to warrant the inference that in excretion cavities developed in different ways the composition of the secretion is also different. In parts of young and old plants which have an identical histological structure the composition of the volatile oil is similar.

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*

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DORMANCY AND GERMINATION OF COMMON RAGWEED (AMBROSIA ELATIOR L.) SEEDS IN THE FIELD IN HUNGARY

Ambrosia elatior (syn.: *Ambrosia artemisiifolia*) is an annual weed plant introduced in Hungary from Yugoslavia in 1922 (PRISZTER 1960). Its economic importance has gradually increased over the last twenty years; today it is one of the most important weed plants in Hungary. According to the results of weed surveys, in cereals it is the 12th and in maize the 6th most important weed (ÚJVÁROSI 1973). An account of its present distribution and the extent of infestation is given by BÉRES—HUNYADI (1979).

The mature seeds of *A. elatior*, spread in autumn, undergo post-ripening before germinating. To break the primary dormancy low autumn and winter temperatures are required (BASKIN—BASKIN 1977, BAZZAZ 1968, 1970, POVILAITIS 1956, WILLEMSEN 1975a, b, WILLEMSEN—RICE 1972). Alternating temperatures as well as light promote the germination of seeds (BAZZAZ 1968, MAGUIRE—OVERLAND 1959, POVILAITIS 1956, WILLEMSEN 1975a). Oxygen and ethylene also play a role in breaking the dormancy (BRENNAN *et al.* 1978). The mechanisms of primary and secondary dormancy were studied in detail by BASKIN—BASKIN (1977), BRENNAN *et al.* (1978) and WILLEMSEN—RICE (1972).

The present experiments were aimed at studying how the seeds of *A. elatior* germinate in field and laboratory circumstances under Hungarian conditions.

Mature seeds of *A. elatior* were collected on 1 November 1976 in the trial grounds of the Keszthely University of Agricultural Sciences, from an area not treated with herbicides. The seeds were cleaned, dried for 4 days at 20–25 °C, sorted, then stored until 8 November 1976 when the experiment was set up. The study included 4 treatments.

Treatment 1

Thirty pots of 30 cm diameter were sunk in the ground and filled with a mixture of forest soil, peat and sand (3 : 2 : 1 v/v/v). The pots were protected from the birds by a wire netting. Supplementary irrigation was not applied in the treatment. The germination of seeds was evaluated every week over a year; seeds found to have germinated or developed into seedlings were removed on each occasion.

Treatment 2

The seeds were planted 2.5 cm deep in the soil. The lay-out and evaluation were the same as in Treatment 1. The data of air and soil temperatures, as well as the amount of precipitation are shown in Table 1.

Table 1

Average air and soil temperatures and rainfall

1976/77	Air	Soil			Rainfall, mm
		2 cm	5 cm	10 cm	
November	6.7	6.6	6.9	7.2	39.8
December	0.6	1.2	1.6	2.1	97.9
January	0.8	0.2	0.3	0.4	49.6
February	4.6	4.3	4.4	4.4	51.3
March	8.8	8.2	8.4	8.5	39.7
April	8.9	9.3	9.4	9.3	46.8
May	16.0	18.4	18.4	18.3	16.1
June	19.6	23.1	23.0	22.9	47.0
July	19.9	23.9	22.4	22.2	70.2
August	19.3	21.1	20.9	20.5	50.9
September	13.8	15.8	15.7	15.8	43.9
October	10.7	10.9	11.1	11.5	20.1
November	5.8	5.8	6.1	6.6	76.3

Treatment 3

Prepared seeds of *A. elatior* were put by hundreds in 10×10 cm bags made of plastic net and placed on the soil surface in the field. The experiment lasted for one year and evaluation was made every week. On each occasion 600 seeds were transferred to the laboratory and washed clean with water. Half the seeds (300) were germinated at 23 °C in the dark, the other half in the light, in Petri dishes 17 cm in diameter.

Treatment 4

The seeds were prepared as described for Treatment 3. The bags containing the seeds were placed 8 cm deep in the soil. Every week during the experiment 300 seeds were lifted from the soil. After that, seeds having germinated in the soil were counted, while the rest were cleaned, then placed in 17 cm Petri dishes and germinated in the light at 23 °C.

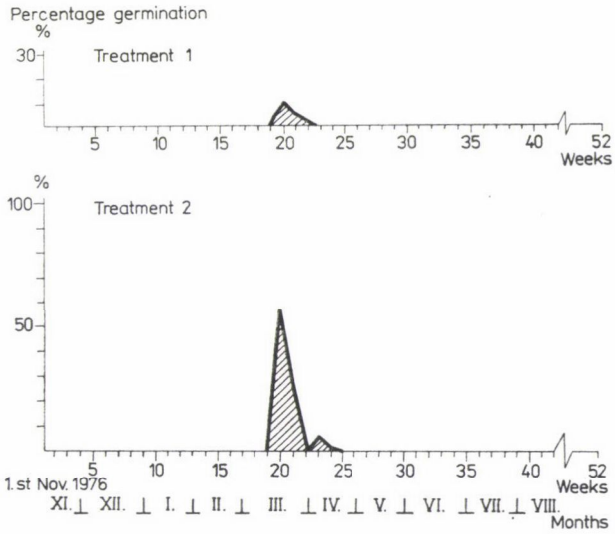

Fig. 1. Field germination of *A. elatior* seeds. Treatment 1. Seeds on soil surface. Treatment 2 Seeds 2.5 cm deep in the soil

Treatments 1 and 2

Under field conditions the germination of seeds both on the soil surface and 2.5 cm deep in the soil started on 17 March (Fig. 1). The seeds required a soil temperature higher than 8–9 °C to start germinating. Germination lasted from 17 March to 21 April. Fourteen per cent of the seeds on the soil surface and 84% of those in the soil germinated. Under the influence of meteorological factors the seed-coats of a considerable proportion of the seeds on the soil surface broke during the winter and the germs died.

Treatments 3 and 4

In the case of seeds transferred from the field to the laboratory germination started at the beginning of January at a temperature of 23 °C (Fig. 2). This means that the primary dormancy of the seeds ended by the beginning of January. From then on they were in a state of enforced dormancy with the temperature as the inhibiting factor. As soon as the inhibiting factor had ceased to exist the seeds began to germinate. The method of storage and the presence of light did not influence the time of breaking the primary dormancy. In the presence of light the germination percentage was higher than in the dark. On a year's average 66% of the seeds kept on the soil surface germinated in the laboratory in the light, and 41% in the dark, while those stored 8 cm deep in the soil showed an average germination of 68% in the light. From the beginning of January till the middle of March the rate of germination increased, while from the middle of March to the end of August it remained on the same level. From the middle of August the germination declined (45–50%) but did not totally stop.

After maturing, the common ragweed seeds were in a state of primary dormancy. The primary dormancy is under hormonal control (WILLEMSEN—RICE 1972). Under field conditions it broke by the beginning of January. WILLEMSEN (1975b) pointed out the breaking of primary dormancy in the United States at the end of January. To break the primary dormancy stratification is needed (WILLEMSEN—RICE 1972, WILLEMSEN 1975a). WILLEMSEN (1975a) found stratification at 4 °C to be the most efficient in breaking the dormancy. POVILAITIS (1956) cooled down seeds in the state of primary dormancy to 1–7 °C; four weeks of precooling increased the rate of germination to 69%. In the experiment the seeds passed from primary dormancy to a phase of enforced dormancy because of the low January temperature. Germination in the field lasted for about one month—from the middle of March to mid-April. According to the data of three successive years field germination took place in almost the same period, with 1 or 2 week differences (BÉRES—HUNYADI unpublished). Thus, the beginning and end of field germination were 17 March and 21 April in 1977, 7 April and 12 May in

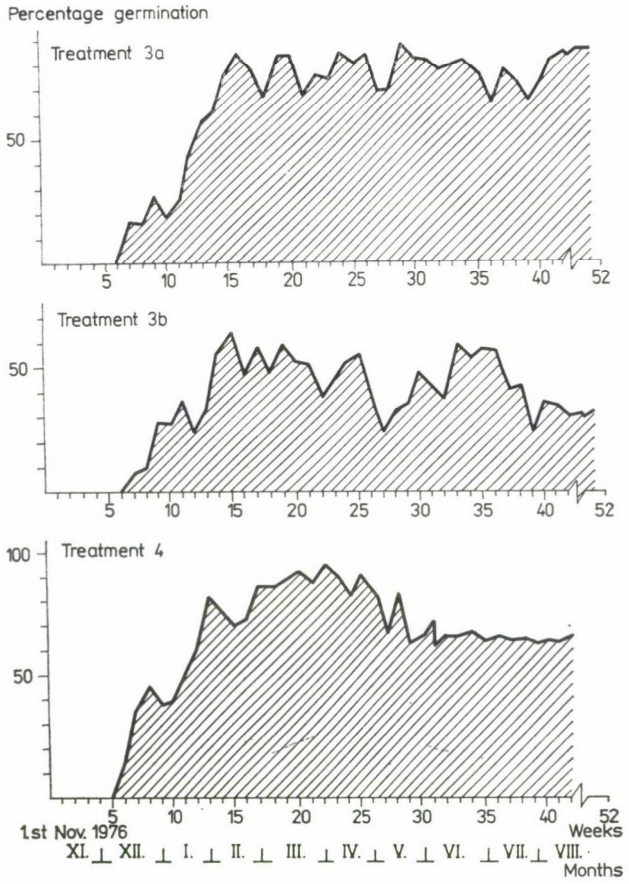

Fig. 2. Laboratory germination of *A. elatior* seeds. Treatment 3a. Seeds on soil surface in the field and laboratory germination in light weekly. Treatment 3b. Seeds on soil surface in the field and laboratory germination in dark weekly. Treatment 4. Seeds 8 cm deep in the soil and laboratory germination in light weekly

1978, 23 March and 28 April in 1979, respectively. In the germination period the average temperature of the soil was 8–9 °C.

By the end of April or in May the seeds in the field entered the stage of secondary dormancy. At that time the soil temperature suddenly rose (18.4 °C in May). The secondary dormancy of the seeds is probably induced by the high soil temperature. This agrees with the results of TAYLORSON (1970, 1972), STOLLER—WAX (1974) and WILLEMSEN (1975a). In the experiment of WILLEMSEN (1975a) dormancy was not induced as long as the soil temperature was below 20 °C.

Under laboratory conditions the germination of the seeds was stimulated by the light (Fig. 2). This agrees with the statements of BAZZAZ (1968), MAGUIRE—OVERLAND (1959), POVILAITIS (1956) and WILLEMSEN (1975a).

*

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EFFECT OF ECOLOGICAL FACTORS ON GERMINATION AND VIABILITY IN APERA SPICA-VENTI L. (P. B.) AND ON THE MORTALITY OF SEEDLINGS AT THE ONE- AND TWO-LEAF STAGES

Hardly any informative data are available on the germination optimum of *Apera spica-venti* L. under natural conditions. Data on seasonal changes in germination have mostly been published by authors engaged in research on chemical weed control. In Sweden KOLK (1947) studied the germination optima of annual weed plants germinating in autumn and overwintering and found the germination optimum of *Apera spica-venti* under natural conditions to be +11 °C. Under the climatic conditions of Germany, *Apera spica-venti* is capable of germination all the year round and appears in large numbers in autumn and spring. The ability to germinate at any time of the year is attributed by the author not only to the regulating effect of temperature, but also to the above-average precipitation in the summer period (KOCH 1968). On the area sown with winter cereals in Sweden, this weed was found to have two separate, autumn and spring, germination periods (AAMISEPP—AVHOLM 1970).

When attempting to explain the varying efficiency year by year of the chemical control of *Apera spica-venti* ZEMÁNEK (1971) found that spraying proved effective when the treatments were adjusted to the seasonal changes in the germination peak. Studying the ecological background of the appearance of the weed species in Poland, ROLA (1968) established that the local extent of infestation by the weed was influenced by the amount of precipitation in spring. The annual weed *Apera spica-venti* has become perfectly adapted to the climatic conditions of Hungary. It survives the hot, dry summer as a seed, and the damp cold winter in the form of a seedling. The weed has a T_2 habit (ÚJVÁROSI 1973). Under field conditions in Hungary the period most favourable for the germination of the weed and for its control lasts from autumn to spring (UBRIZSY 1969). The seeds of weeds growing under natural conditions are mostly of physiologically heterogeneous composition, consequently the germination process is periodical i.e. it is characterized by longer or shorter intervals (KINZEL 1920).

Biological characteristics of seeds collected in different years and used for examination.

The biological viability of the seeds was determined with Tetrazolium solution according to the principles described in the Seed Test Standard (MSZ 6354-68). The viability of seeds collected in two successive years was 83–85% in 1971 and 78–80% in 1972. The investigations were actually aimed at determining the extent of changes taking place in the germinative ability and germination vigour (rate of germination) of seeds stored in the laboratory under dry conditions. The samples were germinated in 1973; the seeds were placed in Petri dishes (100 in each) in four replications. Germination was carried out in a dark growth chamber at 15 °C for 30 days. Numerical evaluation was made at two-day intervals, when seeds with a 1 mm coleoptyl were removed from the Petri dishes.

Description of a germination experiment performed under natural conditions.

The *Apera spica-venti* seeds were collected in a winter wheat field at Ják, belonging to the Szombathely State Farm, on 11th July 1971 and 22nd July 1972. The samples were dried and cleaned, then the seeds were stored in the dark at 20 °C. Soil samples were obtained from arable areas free of infestation by *Apera spica-venti* on the Devecser and Szombathely state farms. Parallel to the examinations of sandy soils, heavy soils providing less favourable conditions for the weed were also examined. The physical and chemical properties of the soil types are summarized in Table 1.

Table 1

Physical and chemical characteristics of soils at the sites examined

Origin of soil sample	Humus content, %	pH value		Arany's viscosity number	Total N content, mg/100 g	Total P content, mg/100 g	Total K content, mg/100 g
		H_2O	KCl				
Devecser State Farm	0.88	6.6	5.8	23.2	52	9.2	7.2
Szombathely State Farm	1.97	7.1	5.7	40	64	11.3	9.8

Seeds of the same size and colour were planted in pots, 100 in each, filled with the two types of soil, in four replications. The seeds were covered with a 1 cm layer of soil. Sowing was repeated every month in accordance with the life cycle of the weed. The culture pots were placed under natural conditions on the 5th day of every month. The rate of germination was evaluated at 10-day intervals during the ten-month period of the experiment, but with a view to further observations the seedlings were not removed from the pots. Sowing was continued from October until the following June. The mortality rate of seedlings which survived until the one- and two-leaf stages of development was recorded every 10 days in each treatment. The actual course of germination characteristic of the species was studied in a pure stand to avoid competition and to eliminate disturbances in the germination caused by allelopathic effects.

By means of sowing at regular intervals an ecological series was formed, in which the sowing dates and the course of germination harmoniously followed the weather conditions of the successive seasons. Thus, as the seasons changed, the seeds were exposed to ecological effects both favourable and unfavourable for germination. With the aid of the ecological series the seasonal periodicity of germination was established, the air and soil temperatures and the precipitation requirements for the beginning of germination and the germination maxima were determined, and the monthly course of germination and the non-continuous character of the process were analysed.

Tables 2 and 3 show the 10-day means of the 1971/72 and 1972/73 air temperature data registered with a thermohydrograph and the precipitation measured in the open at a height of 50 cm above the soil surface at the meteorological station set up in the trial grounds of the Research Institute for Plant Protection. The periodical changes in germination were studied by following the trends of air and soil temperature and the quantity of precipitation.

Biological characteristics of seeds used in the experiments. The germinative ability of seeds collected in 1971 was 68.2% after 6 months of storage; three years later this value was 65.5%. The germinative ability of seeds collected in 1972 fell from 64.2% to 62%, while seeds collected in 1973 displayed a 47.5% germinability. In a growth chamber at constant temperature the time limit of germination vigour was 8 days. The proportion of seeds germinat-

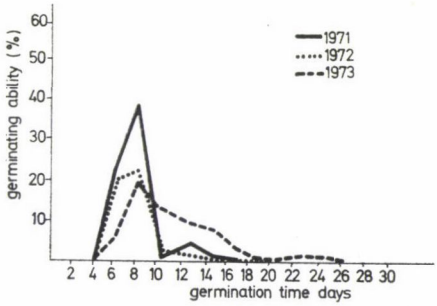

Fig. 1. Length of germination period and germination vigour of *Apera spica-venti* seeds collected in different years

ing in this period was 60% for 1971 seeds, 37.7% for 1972 seeds and 44.7% for 1973 seeds. The length of time required for the seeds to germinate also varied from year to year. The actual germination of 1971 seeds took 16 days, while those collected in 1972 and 1973 required 24 and 18 days, respectively, to germinate. The germination vigour (rate of germination) and the length of the actual time of germination are shown in Fig. 1.

Seasonal changes in the monthly germination total of successively sown seeds are shown in Fig. 2. The germination of seeds planted in the autumn months exhibited an autumn and spring periodicity. The ratio of the final germination percentage for seeds sown in autumn and for those sown in spring reflects the differences in the weather conditions between the two years examined.

In the 1971/72 experimental year the ratio of the monthly total germination percentages for seeds sown in November and December, or in February, March and April is unity (58.2% : 58.2%). In the May of this crop year a facultative tertiary germination peak appeared, which may have been due to the larger than usual (84 mm) amount of precipitation in the period in question (Table 2), and to a temporary fall in the air temperature (10–15th May). The crop year examined was characterized by an unusually early reduction in the temperature in November 1971, and by mild weather in December. Ever since meteorological data had been regularly recorded it was the first case that on 22nd and 23rd December temperatures as high as 14.1 and 12 °C, respectively, were measured. The temperature mean in January exceeded the average over many years by 2.5 °C. The amount of precipitation in the winter months did not reach the annual average anywhere. In the spring months the weather was colder than usual, and rainier than the previous autumn. In April the amount of precipitation was 18 mm more than the average over many years.

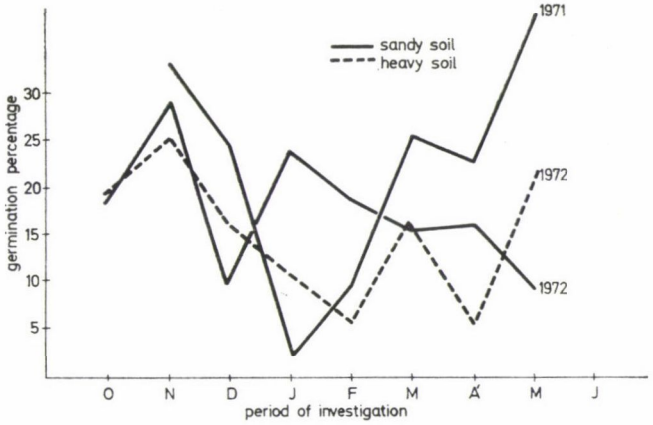

Fig. 2. Seasonal changes in the monthly germination total of *Apera spica-venti* seeds sown as intervals under field conditions

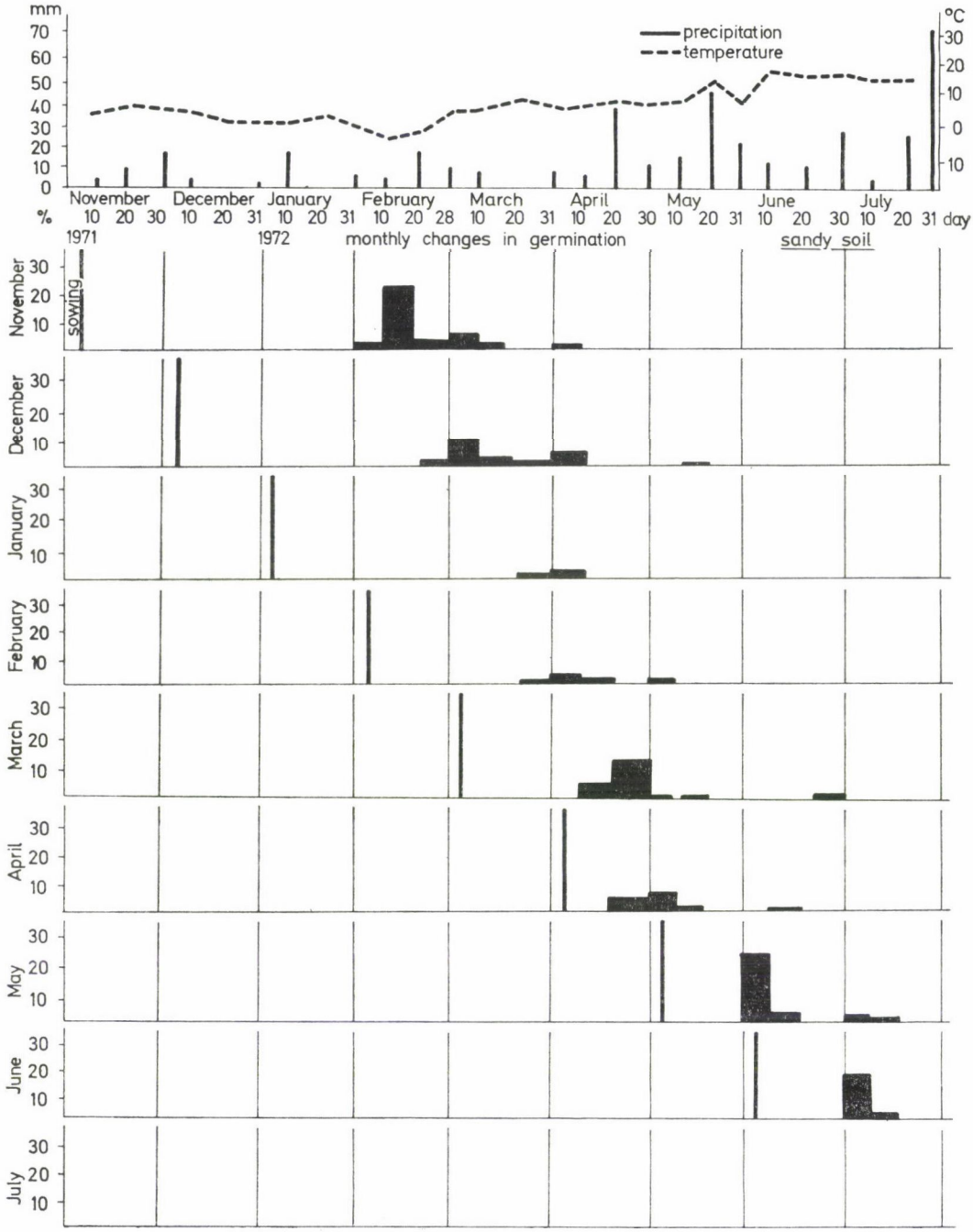

Fig. 3. Average and total values of air temperature and precipitation during the experimental period (trial grounds of the Research Institute for Plant Protection, Budapest)

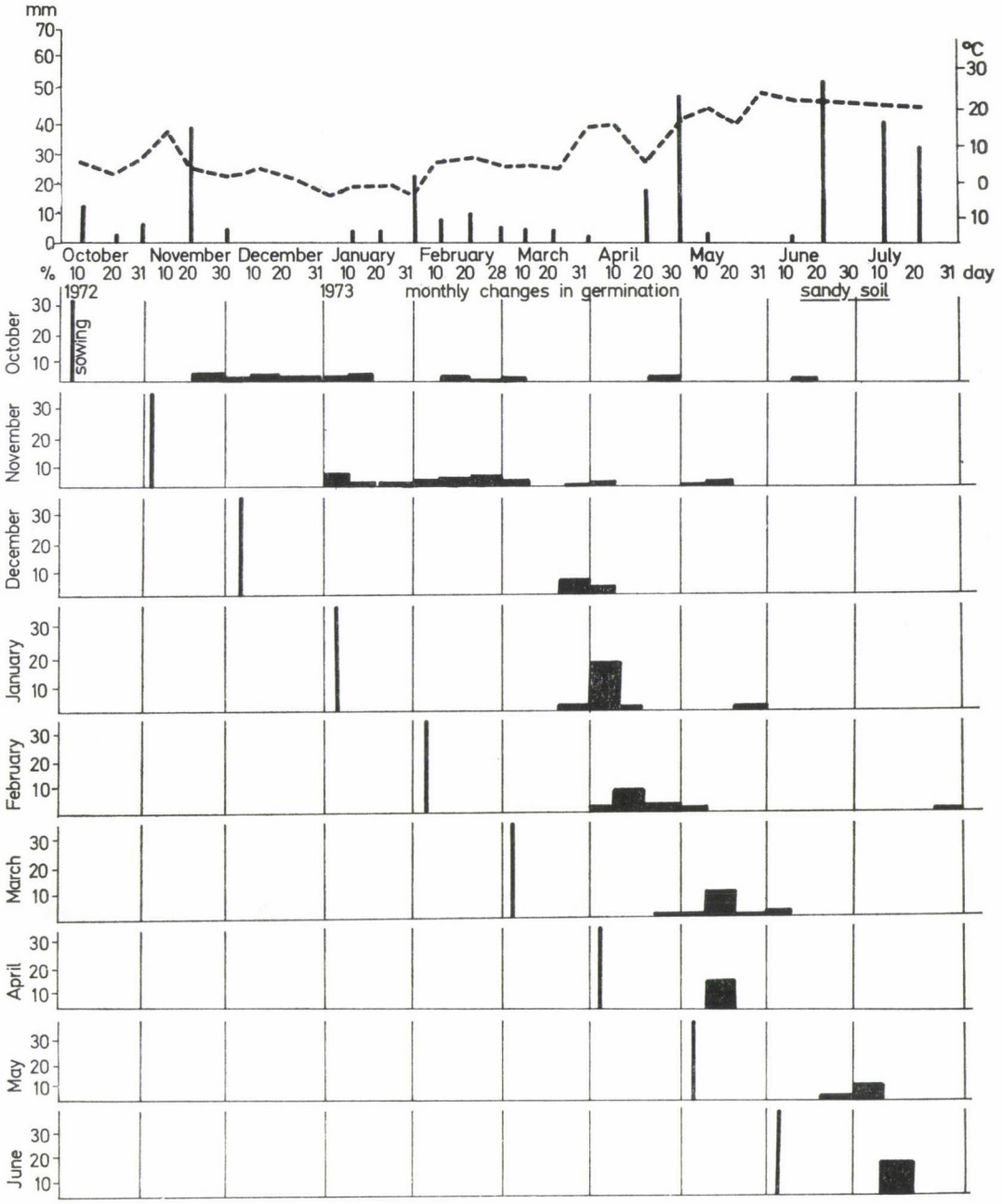

Fig. 4. Average and total values of air temperature and precipitation during the experimental period (trial grounds of the Research Institute for Plant Protection, Budapest)

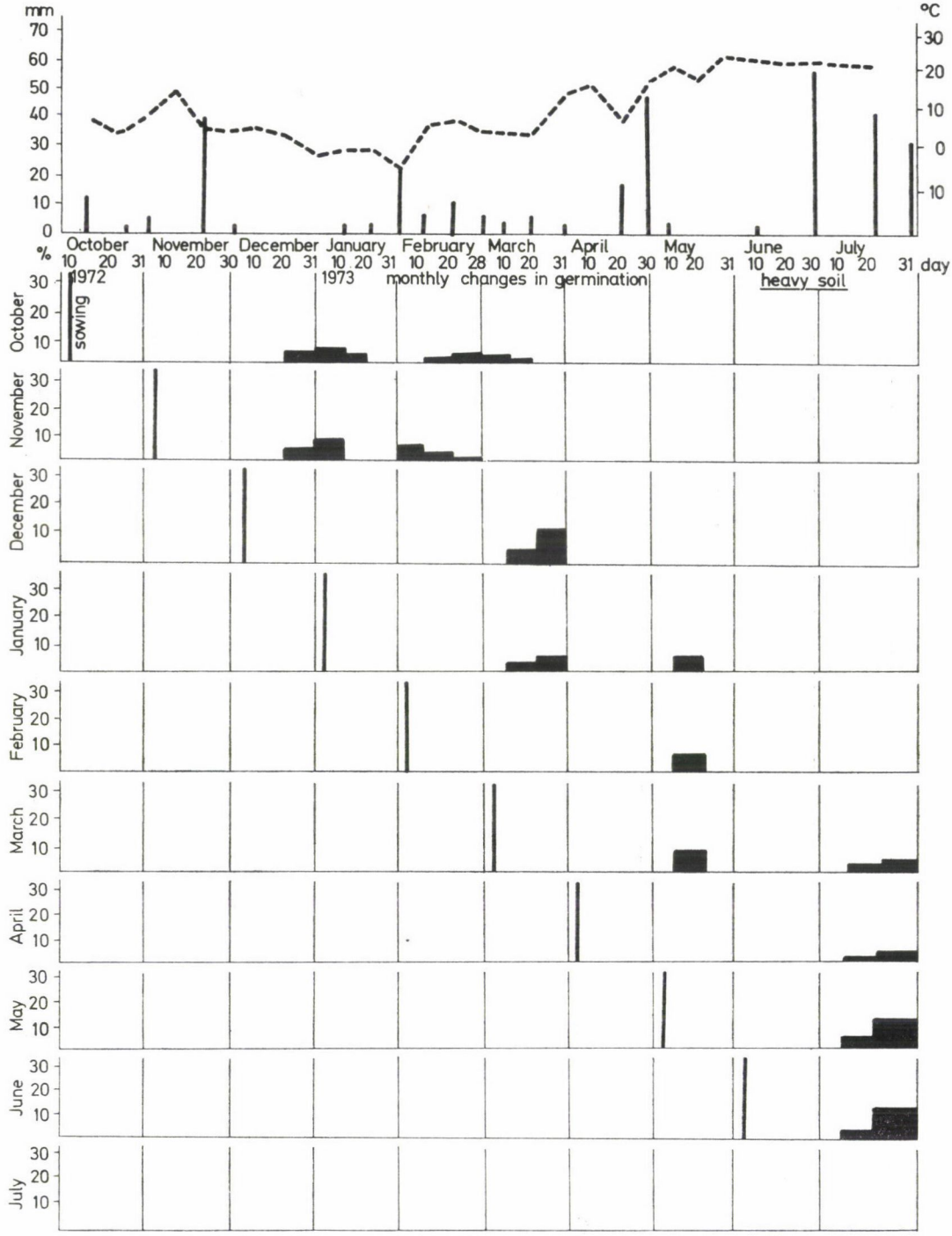

Fig. 5. **Average and total values of air temperature and precipitation during the experimental period (trial grounds of the Research Institute of Plant Protection, Budapest)**

Table 2

Air temperature data for the emergence of seedlings of Apera spica-venti sown at intervals

Months		Site of observation Research Institute for Plant Protection, trial ground 10-day air temperature averages, °C	
		1971–1972	1972–1973
October	10		8.0
	20		6.1
	31		9.2
November	10	4.6	14.5
	20	5.2	5.7
	30	4.8	4.8
December	10	2.2	5.6
	20	1.4	4.0
	31	0.0	−2.7
January	10	0.2	−1.0
	20	1.2	−1.2
	31	−1.5	−2.9
February	10	−5.2	7.0
	20	−4.8	6.1
	28	−2.3	5.8
March	10	2.4	5.6
	20	7.3	5.3
	31	5.0	15.0
April	10	7.2	16.2
	20	7.0	7.2
	30	7.1	17.1
May	10	10.5	20.1
	20	7.2	17.3
	31	16.0	25.3
June	10	14.0	24.9
	20	15.9	24.6
	30	15.0	24.7
July	10	15.5	24.8
	20	17.4	24.6
	31	19.0	24.1

Table 3

Precipitation data for the emergence of seedlings Apera spica-venti sown at intervals (Trial grounds of Research Institute for Plant Protection)

Months		10-day precipitation, mm	
		1971–1972	1972–1973
October	10		12
	20		1
	31		5
November	10	2	0
	20	9	39
	30	12	4
December	10	3	0
	20	0	0
	31	0	0
January	10	16	4
	20	0	4
	31	5	22
February	10	3	8
	20	17	12
	28	10	5
March	10	7	3
	20	0	4
	31	5	2
April	10	3	0
	20	35	18
	30	12	51
May	10	17	3
	20	45	0
	31	22	0
June	10	13	2
	20	12	54
	30	25	0
July	10	3	45
	20	22	33
	31	66	21

In the crop year 1972/73 the ratio of the total monthly germination percentages for the autumn (October, November, December) and spring (February, March, April) months was 56.7% : 56.8%. Of the seeds planted in the autumn 10.1% more germinated. The higher germination percentage of the autumn months can be interpreted as follows: the after-ripening period required for full maturity was shortened by the 39 mm precipitation in November and the unusually mild air temperature (11.6 °C monthly mean temperature). Successive dry periods in the spring appear to have induced a secondary dormancy in the seeds. This crop year was characterized by dry weather and wide temperature fluctuations. December, and the winter months in general, were droughty. The total amount of precipitation in January, February and March was less than 5% of the average over many years. February was particularly mild, though the temperatures in March and April were also higher than usual. The germination percentage of seeds sown in heavy soil in autumn exceeded that of those sown in spring by 31% (Fig. 2).

Comparing the two types of soil, the germination of seeds was 4–12% lower in heavy than in sandy soil (Fig. 2). The lowest germination percentage was obtained for seeds sown in January (2% and 11% in 1971/72 and 1972/73, respectively). The largest number of germs was counted for seeds sown in November and March (34.2% and 28.5% respectively in 1971/72; 25.7% and 15.7% respectively in 1972/73). The length of the dormant period, the dates of the beginning of germination and the germination maxima, and the germination cycles are shown in Figs 3, 4 and 5. Under natural conditions, in the soil, water and atmosphere system of their environment, the seeds begin to germinate at a time when the weather conditions are optimum.

In sandy soil, the seeds lay in the ground without germinating for 30–95 days when sown in autumn, for 43–63 days when sown in winter and for 15–25 days when sown in spring. In the case of heavy soils this seasonal fluctuation in the delay in germination was not observed; the period of dormancy usually ranged from 35 to 95 days. In sandy soil dormancy has a normal course adjusted to the season: the autumn delay in germination increases towards the winter months and decreases in spring when the cold period is over.

Air and soil temperatures and the amount of precipitation at the beginning of germination are seen in Table 4.

Table 4

Environmental factors of the time of beginning of germination

Sowing date	Beginning of germination	Daily mean temperature, °C	Maximum and minimum, °C	Soil temperature (5 cm) °C	Amount of precipitation, mm
1971/72					
November	1st February 1972	1.5	3/0	1.9	0
December	20th February 1972	6	10/2	5.2	0
March	11th April 1972	14	20/8	14.8	0
April	20th April 1972	13.5	18/9	14.4	0
1972/73					
October	21st November 1972	5	10/5	5.8	16
November	2nd January 1973	0	+1/−1	0.8	0
December	20th March 1973	3.5	9/−2	3.9	0
March	21st April 1973	4.2	6/2.4	4.8	14
April	10th May 1973	12	16/8	9	0

According to the date in the table, seeds sown in November and December began to germinate at an average daily air temperature of 0–6 °C and a soil temperature of 0.8–5.8 °C, and those sown in March and April at a daily air temperature mean of 4.2–15.5 °C and a soil temperature of 4.8–14.7 °C, over a two-year average.

The germination period of seeds sown in autumn lasts 3–8 months and is divided into autumn and spring periods; seeds sown in spring complete their germination in 2 months.

After a short period following the beginning of germination, the germination maxima appear with varying numbers of individuals; their seasonal distribution is shown in Figs 3, 4 and 5. The 10-day averages of air temperature at which the germination maxima occur are —1–+5.7 °C for seeds sown in autumn and 7–17.3 °C for those sown in spring in the case of sandy soil, and —1–+5.3 °C and 17.3–24.6 °C for seeds sown in autumn and spring, respectively, in heavy soil. The occurrence of germination maxima was preceded in every season by a period of abundant precipitation: 17–39 mm for seeds sown in autumn and 18–35 mm for those sown in spring.

The monthly course of germination was broken off at irregular intervals.

In rainier years (1971/72) the course of germination is usually divided into two phases, while in droughty years the number of phases rises to 2–4. The monthly course of germination for seeds snow in heavy soil is divided into two distinct phases (Fig. 5). In winter, under a 5–8 cm snow cover and at a 10-day air temperature mean of —2.3–+5.8 °C germination is able to continue. Under natural conditions the germination of the seeds reaches a maximum within 10–12 days. Compared to the established percentage viability, 49.8–50.5% of the seeds did not germinate; they either remained in a state of primary or secondary dormancy, or were physically or biologically damaged in the soil.

Factors causing mortality in seedlings at the one- and two-leaf stages.

Seedlings with 1–2 true leaves are badly damaged by extreme fluctuations of temperature and precipitation. The mortality rate and critical periods for the seedlings are seen in Table 5.

Table 5

Rate and date of seedling mortality

Sowing date	Beginning of injury	Observation of total mortality	Mortality rate, %
1971/72			
Autumn	1–20th February	1–10th April	15.3
Spring	10–31st March	20–30th April	1.0
1972/73			
Autumn	20–30th March	1–10th May	5.3
Spring	20–30th March	1–10th May	5.8
	20th April–10th May	20–30th May	1.7

Biological damage leading to the death of the seedlings may have been caused by the cold, dry weather with temperature maxima 3–5 °C below zero, or by the period poor in precipitation which set in suddenly and lasted for 10–20 days (5 mm precipitation in 1972 and 2 mm in 1973). Further damage occurred at the end of April and the beginning of May when the leaf blades of the seedlings became covered by powdery mildew [*Erysiphe communis* (Wallr) Link.]. The roots were not sufficiently developed at that stage to replace the water lost by the increased evaporation, so the seedlings began to die off.

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DYNAMICS OF ACCUMULATION OF STORED MATERIAL AND CHANGE OF WATER CONTENT IN OPAQUE-2 AND NORMAL MAIZE KERNELS

Maize containing the o_2 gene has not become popular in spite of its better protein quality. The reason is that the o_2 gene which is responsible for the high lysine content has a many-sided adverse pleiotropic effect manifest, among other things, in the relatively slow water discharge of the kernel and its high water content at the stage of full maturity. PURDY—CRANE (1967) and GUPTA—KOVÁCS (1973) explain these phenomena as being due to the thicker pericarp, SISOEV—PILYANEVA (1976) as being due to the significantly higher ash content of the o_2 kernels, while NAUMENKO—KIRPA (1978) attribute them to the higher porosity.

The results of investigations on the process of maturing in other plant species (KISS—MÁTHÉ 1978) suggest that the varying relation between organic matters (sugar, starch, protein) and the volume of the kernel may also cause differences in water content between normal and opaque-2 kernels during maturing. To verify this theory experiments were carried out in 1978–1979.

The experimental material consisted of a maize strain with normal endosperm and its o_2 analogue produced and kindly placed at our disposal by Dr. István Geczki, Department of Plant Breeding, University of Agricultural Sciences, Gödöllő. The plant number was determined by the number of selfings to be carried out. The examinations were performed on kernels from ears collected every week over a period of eight weeks from the 17th or 21st day after pollination. The dry matter, water, sugar, starch, protein and lysine contents per kernel were determined, taking the number of kernels (50), kernel weight and percentage value into consideration. The volume of the kernel was established with the help of the weight of the kernel and its cubic weight determined in water.

The starch was determined by Bertrand's method after the sugars had been dissolved out with alcohol and the residue hydrolysed for 3 hours with 1% HCl. The difference between total carbohydrates and starch gave the amount of sugar. The protein nitrogen was measured using a Spekol photometer, with the aid of Nessler reagent, after liberation by the micro-Kjeldahl method. The amount of nitrogen was read from the NH_4Cl standard curve, and the crude protein was given as $N \times 6.25$.

The liberation of amino acids was carried out by hydrolysis with 6n HCl. The filtrate was applied on a FIXION 50×8 thin layer chromatogram, eluated with sodium citrate buffer at pH 5.1 and developed with ninhydrin. The amount of lysine was established using a Videodensitometer. The computer attached to the apparatus writes out the percentage value of lysine. The examination was carried out with 2–3 replications for each ear. The data were checked by variance analysis. The correlations were studied by regression analysis with two or three independent variables (SVÁB 1973).

The examinations showed that until the 28th (1979) or 60th (1978) day after pollination, as long as the dry matter content was lower than 50%, there was only a slight difference

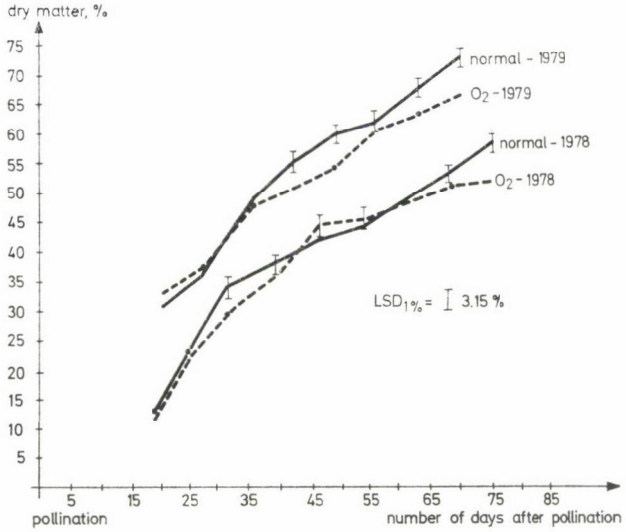

Fig. 1. Percentage dry matter content of maize kernels during maturation

in the dry matter accumulation in the kernel between the two forms of maize (Fig. 1). A significant difference in dry matter content could only be observed in the second phase—the so-called "filling period"—of kernel development.

The analogues differed in lysine content. Figure 2 clearly shows that the kernels of opaque-2 maize had a higher lysine content on each occasion of sampling than those of the normal form. No significant difference could be demonstrated in the protein nitrogen content of the maize kernels.

Figure 3 shows the changes in the water and starch contents and in the volume of the kernel. The analogues exhibited differences in the dynamics of water content in the course of maturing. In 1979 the water content in kernels of normal maize reached a maximum on the 28th day, and in the o_2 kernels not until the 49th day. In 1978 a slower inflow of water

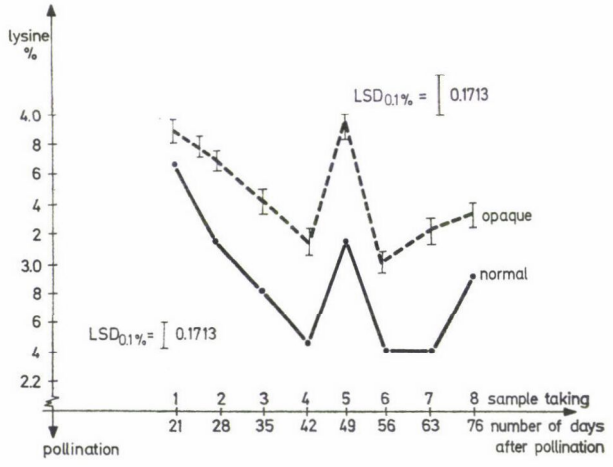

Fig. 2. Percentage changes in the lysine content of kernels during maturation

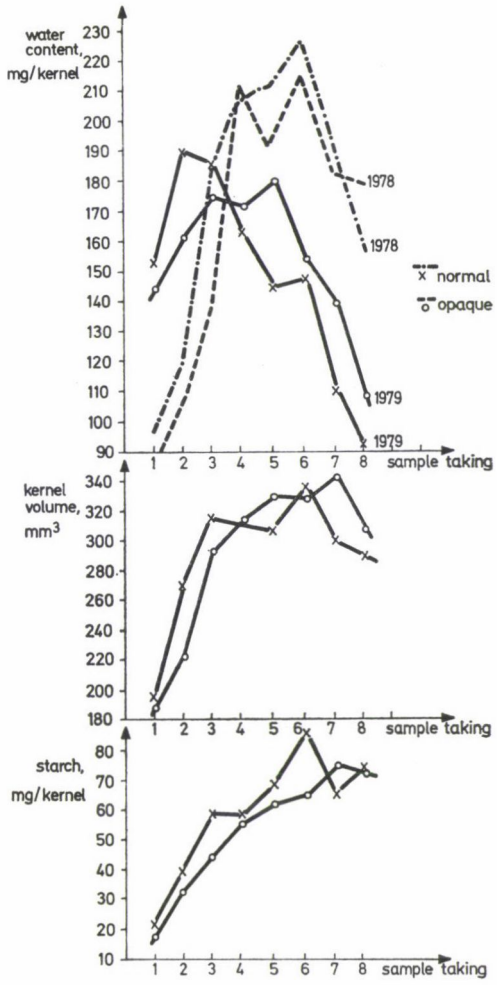

Fig. 3. Changes in water content, kernel volume and amount of starch in the course of maturing

was observed. The maximum water content was measured on the 56th day in both analogues. The dynamics of the factor examined was greatly influenced by the crop-year (being slowed down in 1978 and accelerated in 1979) in the course of kernel development, though the differences between the analogues were not substantially affected.

Since for the other parameters similar results were obtained in both years, an evaluation of the 1979 data is presented below. Kernel volume and starch content reached maximum filling later in the o_2 analogue than in normal maize. Correlations between water and starch contents and kernel volume were first evaluated by single factor regression analyses. The calculations show that there is a positive linear relationship between starch content and kernel volume in both forms of maize (Fig. 4).

In opaque kernels we found the regression between sugar and starch content could be described with a quadratic polynomial (Fig. 5), while a positive linear correlation was found between the sugar and water contents (Fig. 6). In normal kernels the correlation was not significant.

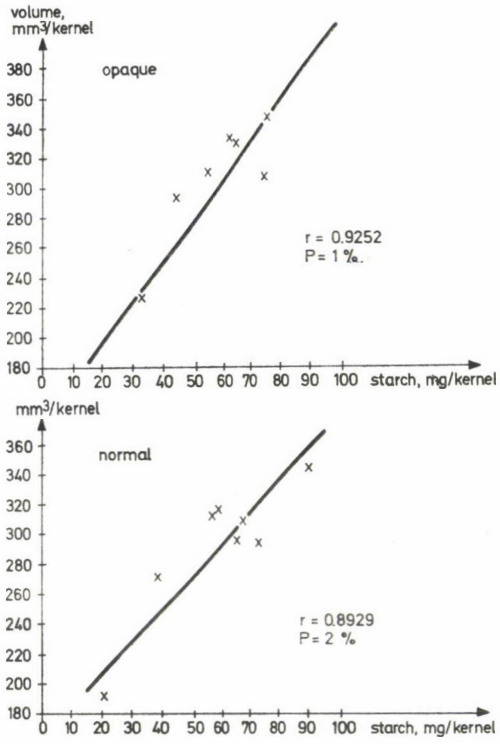

Fig. 4. Correlation between kernel volume and starch content (1979)

A closer approach to changes in the water content of kernels during maturation was made possible by regression analyses with two or three independent variables. The quantities of organic matters examined and listed above figured as independent variables, together with the volume of the kernels, and the water content per kernel as a dependent variable.

On the basis of the calculations the sugar, the starch and the volume of the kernels jointly determine the water content of the kernel. According to the significance tests the starch content proved to be the most important factor; it exercised a strong negative effect on the water content of the kernel both in the normal (a) and opaque (b) forms, as confirmed by the following equations:

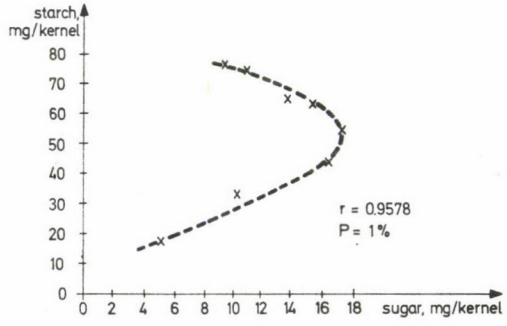

Fig. 5. Relationship between starch and sugar contents in opaque maize kernels (1979)

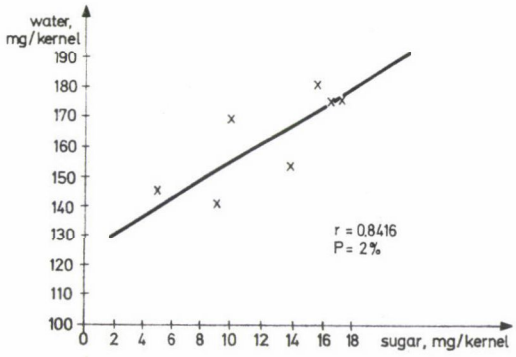

Fig. 6. Relationship between water and sugar contents in opaque maize kernels (1979)

$$\text{(a)}\quad Y = 30.68 - 3.04\,X_1 - 3.47\,X_2 + 1412\,X_3$$

$$\text{(b)}\quad Y = 54.34 + 1.79\,X_1 - 1.98\,X_2 + 637\,X_3$$

According to the equations:

1. the difference was in the extent to which the starch (X_2) influenced the water discharge, suggesting that different starch structures may have a modifying effect on the water content;
2. the effect of sugar content (X_1) on the water content was not significant in either form;
3. the positive effect of kernel volume (X_3) was significant only in the case of normal maize kernels.

In view of the varying role played by kernel volume, of the non-significant difference in the dynamics of starch quantities, and of the close linear relationship between starch content and kernel volume, investigations were begun on the role of different kernel volumes.

To furnish evidence, the change over time in the volume per unit starch content was examined. Figure 7 clearly shows that in normal maize the volume per unit starch content was smaller than in the opaque analogue throughout the process of maturing. As further proof, the correlation between volume per unit starch content and the water content of the kernel was also examined.

As seen in Fig. 8, in normal maize a higher water content is associated with the volume per unit starch content than in the o_2 analogue. Thus, if at the same period of time there is more water in the normal maize kernel, yet the volume per unit starch content tends to be larger in the opaque kernel, this proves the larger starch volume and greater internal porosity of the opaque analogue.

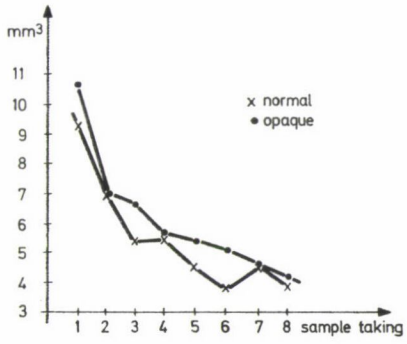

Fig. 7. Volume per unit starch content

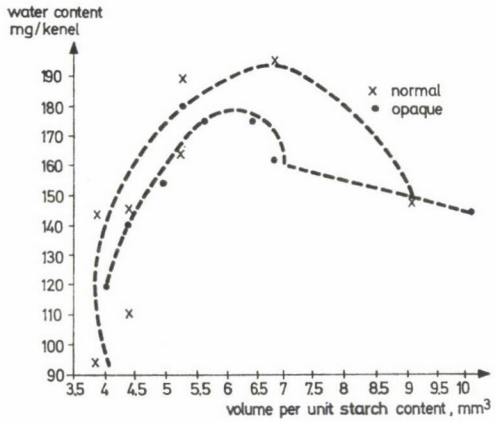

Fig. 8. The correlation between volume per unit starch content and water content of kernels

Since the strong effect of starch on the water content of the kernel has already been demonstrated, it would appear to be proven that the difference in starch structure between normal and opaque maize kernels is, in addition to other factors known from the literature (BAENZIGER—GLOVER 1979, PILYANEVA 1978, RYADCHIKOV—LEBEDEV 1977, TOLLENAAR—DAYNARD 1978), an important factor in the different extents of water discharge. The joint examination of these factors will be continued in order to determine the relative effects.

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EFFECT OF DEFOLIATION ON PRODUCTIVITY OF GRAIN SORGHUM (SORGHUM BICOLOR L. MOENCH)

Field experiments were conducted to determine the effect of defoliation on the yield and yield components of grain sorghum hybrid CSH 5 raised in a dense plant population. Although half defoliation had little effect on the yield/ha, it tended to reduce grain weight/plant and grain number/panicle to some extent. In contrast to this, complete defoliation significantly reduced grain yield/ha to the order of 44–52%, 75–85% and 81–85% when defoliated at 30 days, 50% booting stage and 50% flowering stage, respectively. These yield depressions mainly accrued from reduced grain weight/plant and grain number/panicle and not a great deal from reduced 1000-grain weight. The contribution of the panicle (inclusive of leaf sheath, stalk and peduncle) to panicle weight and grain weight/plant was in the range of 26–27% and 16–31%, respectively.

Plant density is one of the important factors determining sorghum grain production. In an earlier report it was concluded that a planting geometry of 45×12 cm or 60×9 cm accommodating 180 000 plants/ha was optimum for sorghum grain production (PAL *et al.* 1978), although a plant stand of more than 180 000 plants/ha appeared to be advantageous for the sorghum hybrid CSH 6, which has a semi-erectophyle canopy (PAL *et al.* 1978). This indicates that sorghum productivity could be further increased by raising an erectophyle cultivar that might perform better in dense plant stands. It was therefore thought necessary to determine the effect of artificial defoliation, thus simulating an erectophyle canopy in CSH 5, a hybrid with a planophyle canopy, on the yield and yield components in a dense plant stand.

Field experiments were conducted in the rainy seasons (June to October) for two consecutive years in 1978 and 1979 at the Livestock Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar. The experimental site is situated at 29° N latitude, 79.3° E longitude and at an altitude of 243.84 metres above mean sea level, and enjoys a humid subtropical climate in the foothills of the Shivalik Range of the Himalayas. The soil of the experimental site was fertile silty loam, high in organic carbon (1.41%), available phosphorus (28 kg P/ha) and available potassium (350 kg K/ha), with a neutral reaction (pH 6.8).

The experimental treatments consisted of two control treatments, one with optimum plant population (180 000 plants/ha) and the other with a dense plant stand (225 000 plants/ha), which were compared with half and complete defoliation at 30 days after planting, 50% booting stage and 50% flowering stage in a crop raised with a dense plant population. Half defoliation treatments were effected by cutting off the distal half lengths of the leaf blades of the entire canopy, whereas complete defoliation was effected by detaching the leaf blade from the leaf sheath. All the treatments were arranged in a randomized block design with four replications. Gross and net plot sizes were 7×3.6 m and 6×2.7 m, respectively. The test cultivar was hybrid CSH 5.

Planting was done by dibbling two seeds/hill in furrows opened manually 45 cm apart using a hand-operated "Planet junior" furrow opener. The plants were thinned out 15 days later to one in each hill. The crop was uniformly fertilized with 80 kg N/ha, 26 kg P/ha and 33 kg K/ha using urea, diammonium phosphate and muriate of potash. Half the quantity of N and the full quantity of P and K were applied as basal dressing, and the other half of the N was top-dressed 30 days after planting. A recommended dose of 15 kg "Thimet" granules/ha was applied in the furrows at the time of planting as a prophylactic measure against shoot fly damage to the crop. Manual weeding ensured a weedfree condition in the crop field up to 30 days after planting. Grain yield/plant and its components were studied on five randomly selected plants from the net plot area, whereas grain yield/ha was determined by harvesting the crop from the entire net plot area. Yields were standardized at 14% moisture at oven-dry weight.

A perusal of the data summarized in Table 1 reveals an almost identical response to defoliation with respect to yield and yield components in both years. In 1978, the per hectare grain yield levels in the two control treatments were at par with each other. As compared to the control, half defoliation, irrespective of the stage at which defoliation was carried out, did not result in a reduction in grain yield/ha. By contrast, complete defoliation dangerously reduced the yield/ha at all stages of growth. For instance, complete defoliation reduced the yield/ha to the order of 52%, 85% and 81% when effected at 30 days, 50% booting stage and 50% flowering stage, respectively. The effect of defoliation on panicle weight/plant and grain weight/plant was at variance with that observed for yield/ha. Complete defoliation at 30 days had no effect on panicle weight and grain weight/plant, while there was a significant

reduction to the order of 73% and 65% in panicle weight and 84% and 79% in grain weight/plant when the plants were completely defoliated at 50% booting and 50% flowering stage, respectively.

In 1979, as compared to the control with an optimum plant stand, half defoliation at any stage had no effect on yield/ha. When compared to the control with a dense population, however, half defoliation at 50% flowering stage depressed the grain yield/ha significantly. Furthermore, complete defoliation at 30 days was less detrimental in reducing the yield/ha than that at 50% booting and 50% flowering stage. For instance, there were 44%, 75% and 85% reductions in yield/ha when the plants were completely defoliated at 30 days, 50% booting stage and 50% flowering stage, respectively. Panicle weight and grain weight/plant were identical for both control treatments. As compared to the control with a dense plant stand, defoliation at 50% booting and 50% flowering stage depressed the panicle weight

Table 1

Yield and yield components of sorghum hybrid CSH 5 as affected by defoliation at various stages of crop growth during 1978 and 1979

Treatments	Grain yield (kg/ha)	Panicle wt./plant (g)	Grain wt./plant (g)	Grain number/ panicle	1000 grain wt. (g)
	1978				
1. Control (180 000 plants/ha, P_1)	3130	81	56	—	—
2. Control (225 000 plants/ha, P_2)	3566	71	62	—	—
3. HD* at GS_1 underP_2	3085	53	50	—	—
4. CD** at GS_1 under P_2	1718	53	46	—	—
5. HD at GS_2 under P_2	3093	49	43	—	—
6. CD at GS_2 under P_2	534	19	10	—	—
7. HD at GS_3 under P_2	2860	52	49	—	—
8. CD at GS_3 under P_2	686	25	13	—	—
S.E.±	345	9.2	5.6	—	—
L.S.D. (P = 0.05)	1013	27.0	16.5	—	—
	1979				
1. Control (P_1)	3013	81	53	2789	19.00
2. Control (P_2)	3205	68	58	2937	19.25
3. HD at GS_1 under P_2	3285	49	44	2120	20.75
4. CD at GS_1 under P_2	1795	48	36	1694	21.25
5. HD at GS_2 under P_2	2981	44	41	2247	18.25
6. CD at GS_2 under P_2	819	18	12	744	15.50
7. HD at GS_3 under P_2	2404	47	45	2143	21.00
8. CD at GS_3 under P_2	488	23	14	700	20.00
S.E.±	248	6.9	1.9	—	1.22
L.S.D. (P = 0.05)	734	20.1	5.4	—	3.57

* Half defoliation, ** Complete defoliation, GS_1 — 30 days after planting, GS_2 — 50% booting stage, GS_3 — 50% flowering stage.

significantly, while defoliation at 30 days after planting had no effect. Furthermore, the magnitude of the reductions in panicle weight was greater in the case of complete defoliation than that observed in the case of half defoliation. Defoliation treatments also reduced the grain weight/plant significantly, irrespective of the stage and degree of defoliation. Half defoliation resulted in 24%, 30% and 22% reductions as against 38%, 69% and 60% reductions in grain weight/plant owing to complete defoliation at 30 days, 50% booting stage and 50% flowering stage, respectively. In accordance with the grain weight/plant, the grain number/panicle was also reduced due to the defoliation treatments. By contrast, 1000-grain weight was only significantly reduced by complete defoliation at the 50% booting stage.

An overall comparison between various treatments indicates that complete defoliation was detrimental to sorghum productivity mainly due to its depressive effects on panicle weight and grain weight/plant resulting from the reduced number of grains/panicle, and not a great deal to reduced seed size. However, half defoliation had little effect on yield/ha, highlighting the significance of the erectophyle canopy in withstanding the heavy competition in a dense population. This also shows the possibility of further increasing the plant population, thus breaking the present yield plateau when a real erectophyle cultivar is available for sorghum cultivation.

It is interesting to note that the panicles (inclusive of leaf sheath, stalk and peduncle) contributed to the panicle weight/plant and grain weight/plant to the order of 26–27% and 16–31%, respectively (c.f. data corresponding to complete defoliation at booting stage). Similar to our observations, FISCHER—WILSON (1975) reported a 17.9% contribution of the panicle to grain yield under greenhouse conditions. It may therefore be inferred from the above that half defoliation had little effect on sorghum yield, as against the deleterious effect of complete defoliation. The data also indicate the possibility of breaking the present yield plateau provided an erectophyle cultivar is bred and raised with a dense plant population.

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TRANSFORMATIONS OF FERTILIZER N IN THE SOIL AND ITS UTILIZATION BY MAIZE PLANTS

The transformation of nitrogen in the soil cannot be predicted with certainty because many factors are involved, the most important of which are the microbial fauna and the weather, particularly temperature and precipitation (BROADBENT—NORMAN 1947, SCARSBROOK 1965, STEVENSON 1965, RUSSELL—RUSSELL 1967, THOMAS 1970, ALLISON 1973, SMIRNOV—KIDIN 1974, VIETS 1975, KOLEMBRANDER 1978).

It is a well known fact that NH_4^+-N is subjected to immobilization by both the clay minerals of the soil and the microbian fauna, which is why its absorption by higher plants is delayed to a great extent (CAMPBELL *et al.* 1974, SMIRNOV *et al.* 1974, VDEMOVA-RADILKOVA 1977). In the same manner, a significant loss of NO_3^--N could frequently be noted in the soil, because nitrogen in this form is not easily withheld by the soil materials, being easily leached, particularly if the weather conditions (precipitation) are favourable for this process

(STEWARD—ECK 1958, STAICU *et al.* 1974, DOWDELL—WEBSTER 1976, BRETELER 1977). This process of leaching is particularly important due to the relatively large quantities of this form of nitrogen present in the soil. This is so because in addition to the amounts of NO_3^--N deposited in the soil, a large quantity of the NH_4^+-N deposited in the soil is easily transformed to NO_3^--N within the soil system by the activity of autotrophic microorganisms such as Nitrosomonas and Nitrobacter (JANSSON 1958, GUTHRIE—DUXBURY 1978).

The hydrolizable-N includes NH_4^+-N, NO_3^--N and the easily hydrolizable organic-N, while the N_T includes all the forms of nitrogen mentioned above plus the organic nitrogen not available to the plant.

As a result various types of transformations of N can be observed in the soil, as can a considerable number of factors involved with them, thus giving the amounts of the different fractions of N present in the soil at a definite time. Among the factors affecting these transformations mention can be made of the density of the plant population, the amount and time of fertilizer application, the soil conditions, the type of plant, other types of fertilizers, etc. (BIANCO—CALIANDRO 1973, BRAR—KHERA 1977, JOLLEY—PIERRE 1977, MARSCHENER 1977, SHAROV—AKAEMOVA 1977, TERMAN *et al.* 1977, HUSSEIN—HANNA 1978, PETELKAU *et al.* 1978).

In the course of the investigation, an analysis of N_T (Tiurin method), available-N including the NH_4^+-N and NO_3^--N fractions, hydrolizable-N and the $^{14}N/^{15}N$ fractions was made.

Pot experiments were set up in the Institute of Irrigation, Szarvas, in the period 1979–1980. Pots 20 cm in diameter and 25 cm in height with closed bottoms were utilized, each containing 6 kg absolutely dry soil. The following properties were determined in the laboratory (SZLOVÁK 1979):

1. Maximum water holding capacity	49.6% expressed as a % of absolute soil
2. Viscosity index	46
3. Soluble salts (%)	0.14
4. pH in water	6.6
5. pH in KCl	5.9
6. % of humus (Tiurin)	2.4
7. % of N_T (Tiurin)	0.15
8. P_2O_5 (Egner)	4.2 mg/100 g
9. K_2O (Peive)	11.4 mg/100 g

The maize hybrid Mv 580 was used and a soil with a maximum water holding capacity of 70%.

The following nutrients were given per kg dry soil:

N*	400 mg (ammonium nitrate)
P_2O_5	200 mg (superphosphate)
K_2O	200 mg (potassium oxide-potassium chloride).

The fertilizers were well mixed with the soil and then deposited into the pots. Twenty-five plants per treatment were prepared, which were analysed in the four main stages of development (development of shoots, tasselling, grain filling and maturity) with five replications per treatment.

The treatment N*PK was the most important one within the principal stages of development of the plants. The surface of the pots was covered with plastic to avoid evaporation; in this way the loss of water was only due to the plant.

The pots were weighed daily and the water loss was compensated. The increment due to the development of the green parts of the plant was taken into account. The pots were kept in a greenhouse. To supply the plants with natural conditions, a system of rails was utilized to facilitate the transport of the pots.

The fertilizer used was doubly labelled NH_4NO_3 containing ^{15}N in an atomic percentage of 3.4. The treatments performed were the following:

Treatment	g of N	g of ^{15}N
1. Ø	—	—
2. PK	—	—
3. $N_{0.5}PK$	1.2	0.4
4. $N_{1.0}PK$	2.4	0.8
5. $N_{1.5}PK$	3.6	1.2
6. $N_{2.0}PK$	4.8	1.6
7. $N_{2.5}PK$	6.0	2.0

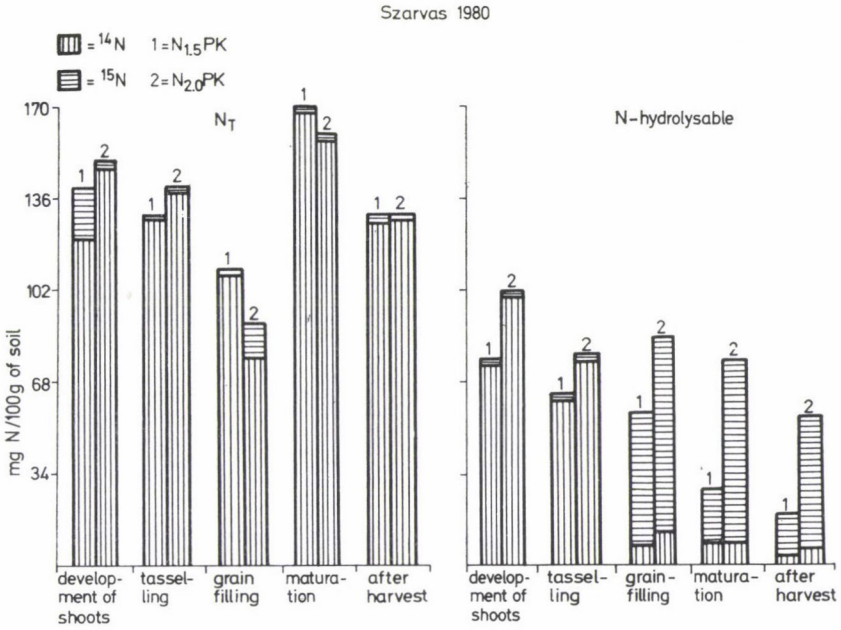

Fig. 1. **Different N-fractions in pot experiments with maize plants**

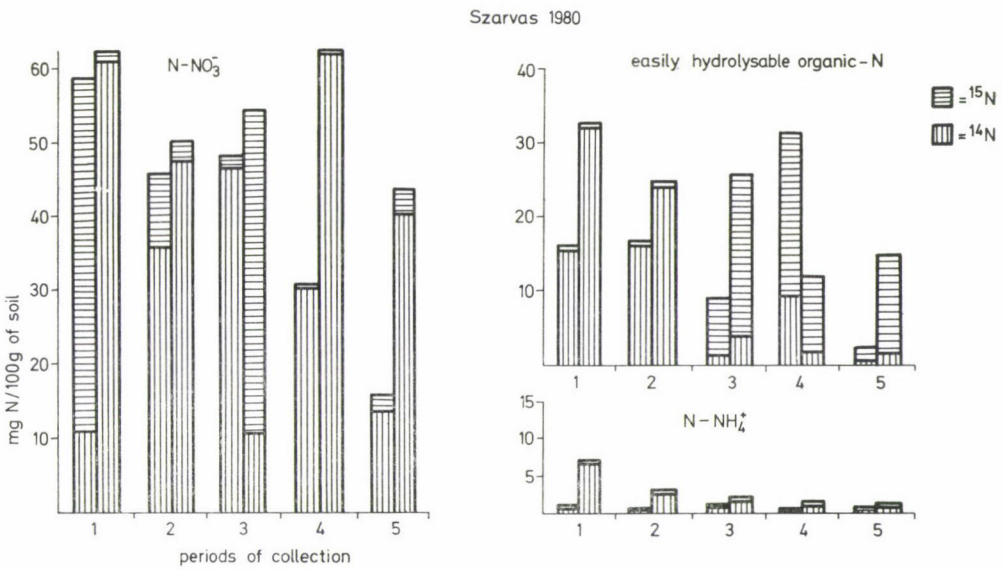

Fig. 2. **NH_4^+-N, NO_3^--N and easily hydrolizable organic-N present in pot experiments with maize plants**

The analyses of N_T, NH_4^+, NO_3^- and hydrolizable N were made by the traditional methods (BACSÓ 1972, DEBRECENI—RÁDY 1975).

Experiments on foliar fertilization were performed on the State Farm, Agárd (KOVÁCS 1981). These experiments were performed simultaneously in two adjacent plots, which differed in the density of plant population and in the amount of fertilizer deposited in the soil. Fifteen plants from the same row were fertilized by spraying a 2% solution of carbamide. Seven ml of solution were deposited per plant with an atomic percentage of 10. The plants were sprayed individually beginning with the lowest leaves.

Another fifteen plants with similar characteristics were used as control in order to know the amount of N_T in plants which do not receive foliar fertilization, i.e. to observe the increment of N_T in the grain brought about by this type of fertilization.

The plants were fertilized in the grain filling stage. The samples were collected during three periods, with five replications each. The first period of sample collection was four weeks after the fertilization and the other two at further intervals of two weeks each.

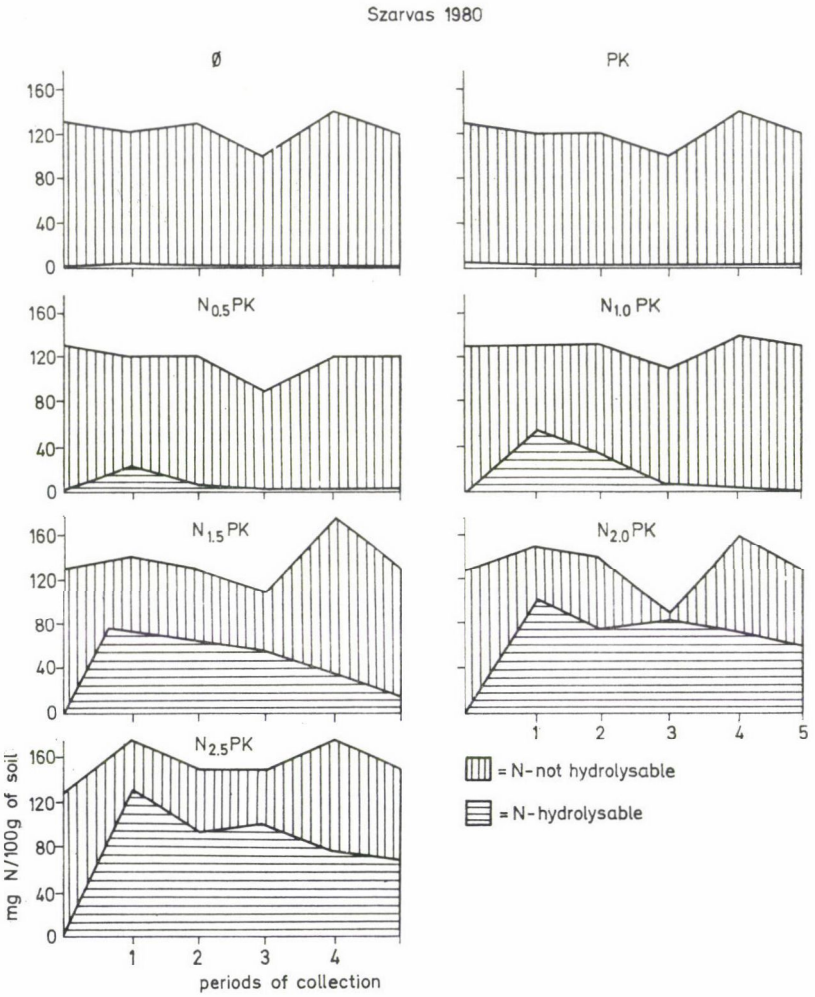

Fig. 3. ^{15}N (fertilizer-N) ratio present in the fractions N_T and hydrolizable-N

In this way samples were obtained for the analysis of N_T and $^{14}N/^{15}N$. The analysis of N_T made using the Kjeldahl method; this method was also used for the $^{14}N/^{15}N$ fraction, a concentrated solution of which was collected in 0.5–1.5 n HCl.

The analysis of hydrolizable-N was made in different horizons of a one-metre profile, again on the State Farm, Agárd, the results of which are shown below.

From the tables and figures presented it can be observed that the fraction of total nitrogen remains constant throughout the periods of sample collection; in addition, the relationship between fertilizer-N (^{15}N) and original-N (^{14}N) also remains constant, the latter being higher in quantity than the former. This is valid for the two treatment analysed by the method of tracers ($N_{1.5}PK$ and $N_{2.0}PK$) (Fig. 1).

The N fraction found in the least quantities in the soil was always NH_4^+-N. This could be caused by two obvious reasons such as the process of nitrification, i.e. favoured by the environmental conditions that also favour the development of the plants, and also by the immobilization caused by the microorganisms of the soil and/or by the clay fraction. In addition it must not be forgotten that the plants are able to absorb part of the N they need in

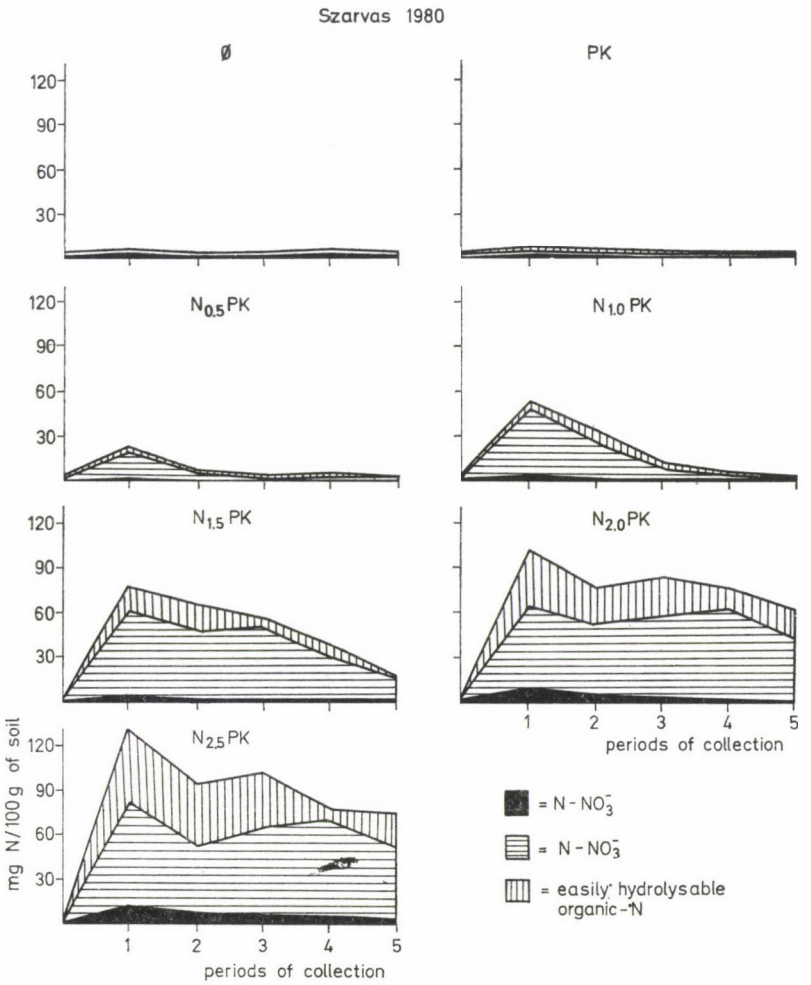

Fig. 4. ^{15}N (fertilizer-N) ratio present in the fractions NH_4^+-N, NO_3^--N and easily hydrolyzable organic-N

this form. In this fraction, as in the N_T fraction, the amount of fertilizer-N is very low in comparison to the amount of original-N.

The NO_3^--N behaves in a manner different to the other fractions analysed, and also differs in the different treatments performed (Fig. 2). For the treatment $N_{1.5}PK$ the ratio of fertilizer-N is higher than that of native-N in the first period of collection (development of shoots), and as the total amount of NO_3^--N present in the soil diminishes, the ratio of fertilizer NO_3^--N also decreases, although it was observed that the latter increased in the last period of collection, but not in a significant manner.

For the treatment $N_{2.0}PK$ the contrary is true, the proportion of fertilizer-N in the first period of collection being very low in comparison to the ratio of native NO_3^--N.

Notwithstanding, the ratio of fertilizer NO_3^--N increases throughout all the periods of collection, reaching its highest level at the third period (grain filling), to decrease later to values more congruent to those obtained for the first periods.

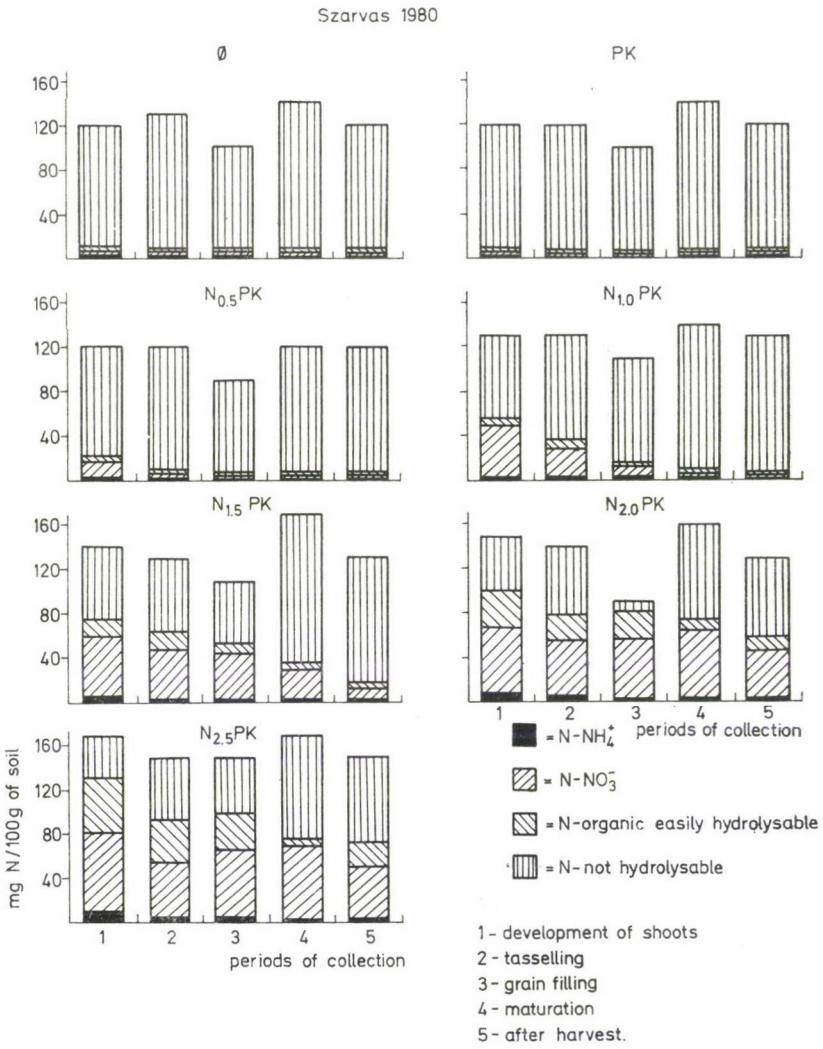

Fig. 5. Hydrolyzable-N and non-hydrolizable-N present in pot experiments with maize plants

It is also worth noting that in the treatment $N_{1.5}PK$, the total amount of NO_3^--N detected in every sampling period decreased as the development of the plant progressed, except for a slight increase in the third sampling period (grain filling). This may have been caused by the enhancement of conditions favourable for the process of nitrification. In the treatment $N_{2.0}PK$ the same increase could be noted but in this case it continued up to the fourth period of sampling, to diminish later in the last period. This may have been caused by the same factors as mentioned in treatment $N_{1.5}PK$ and in addition the second increase may be due to the greater amount of fertilizer deposited, as a consequence of which the production of roots is greater, causing a rise in the amounts of N present in the soil. From the results of the analysis of the hydrolizable fraction of nitrogen this characteristic fact was again observed.

The hydrolizable form of nitrogen present in the soil in the treatments $N_{1.5}PK$ and $N_{2.0}PK$ originated almost totally from the original-N in the first period of sampling, probably because the fertilizer-N was unable to react with the soil material in such a short period of time. It could be observed that as the development of the plant progressed, the ratio of fertilizer hydrolizable-N increased in relation to the total amount of this form of N present in the soil in each period of sampling (Fig. 3).

This can be explained as follows: the nitrogen deposited in the soil as fertilizer is a more readily available source of N for the mechanisms of immobilization (chemical and/or biological) than the original-N. In addition it is also possible that in the first instance the fertilizer-N is not able to become incorporated alone, for various reasons, into the reactions of the soil, which is why it is not easily detected in the hydrolizable fraction of the fertilizer-N; but it is also true that as time passes this N begins to be incorporated into the soil reaction, thus becoming mineralized. It can then be detected in the hydrolizable fraction and is easily available for the plants. On the other hand, it should be taken into account that the environmental conditions that favour the development of the plants coincide in this case with those favouring the process of mineralization. As mentioned above in connection with the NO_3^--N fraction, the production of roots, which increases parallel with the development of the plants and with the dose of fertilizer-N, plays an important role in the rates of hydrolizable nitrogen detected in the analysis. It should also be mentioned that since fertilizer-N is the form absorbed by the plant to the greatest extent, it is also the form present in the greatest proportion in the roots.

With respect to the behaviour of the hydrolizable fraction of nitrogen for the three treatments analysed ($N_{1.0}PK$, $N_{1.5}PK$ and $N_{2.0}PK$) it should be noted that they behave in a similar manner as regards the total amounts present. However, it is worth noting the inverse

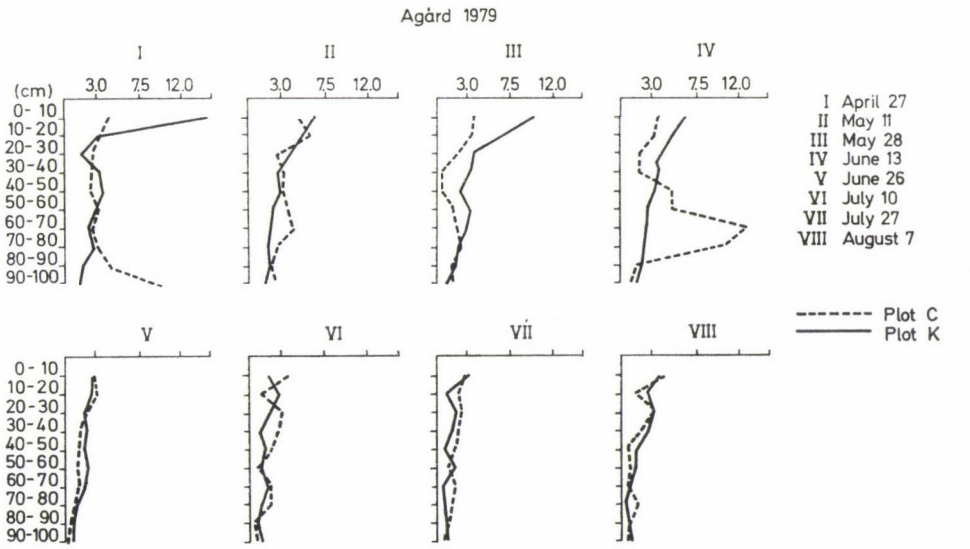

Fig. 6. Hydrolyzable-N present in two profiles with different characteristics

behaviour that takes place among the treatments, taking into account the relationship between the ratio of fertilizer-N and that of original-N. In the treatment with the highest dose of N this relationship remains constant and is the total inverse of that in the treatment with the lowest dose of nitrogen.

In the treatment $N_{1.0}PK$ the rate of fertilizer-N is higher in the first period of sampling and decreases as the total amount of hydrolizable-N present in the soil decreases.

On the above grounds it can be concluded that the fertilizer dose is a determinant factor in the transformations and behaviour of the different fractions of N in the soil. This is the case for the relationship between the amount of hydrolizable and non-hydrolizable-N (Fig. 3), and also for the relationship between the different hydrolizable fractions (NH_4^+-N, NO_3^--N and easily hydrolizable organic-N; Fig. 4). In addition it can be stated that the presence of the nutrients P and K is not an influential factor either in the transformations mentioned above or for the absorption of N by the plants (Fig. 5).

It should be noted that, when referring to the hydrolizable-N present in a one-metre profile of soil, using maize plants as the control, it can be seen that it varies slightly in the last periods of development, but radical changes are noted during the periods of development of shoots and grain filling for each level of sampling in the profile. This behaviour is similar to that of the NO_3^--N an NO_2^--N also present in the profile. The experiment referred to here was performed in two plots which had the same density of plant population but differed in the amount of fertilizer applied. The results proved, once more, that in this case the most important factor was the dose of N, as is shown in Figs 6 and 7.

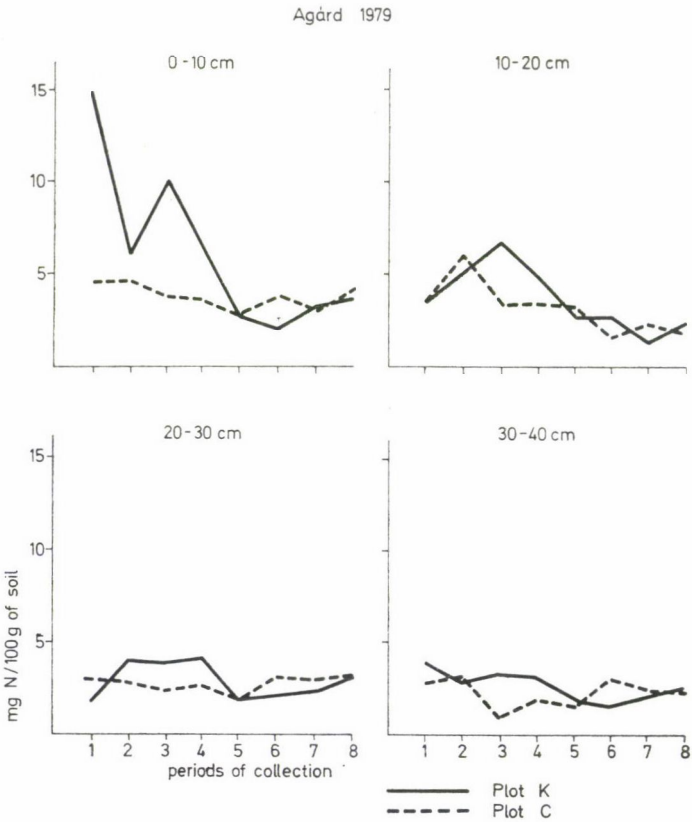

Fig. 7. Hydrolyzable-N present in the first four surface levels (0–40 cm) of a profile with different characteristics

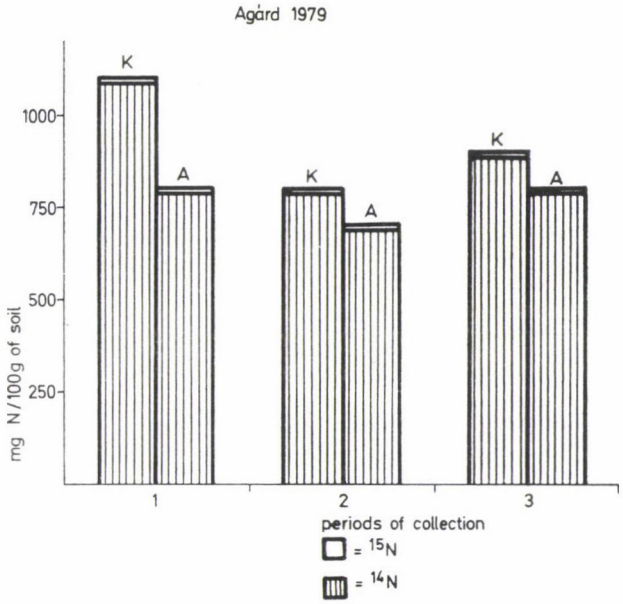

Fig. 8. N_T present in maize grains in plants from two plots with different characteristics with their respective ^{15}N ratios

In reference to the foliar fertilization experiment, performed in two adjacent plots that differed in the dose of fertilizer applied to the soil and in the number of plants per hectare, it was observed that the amount of N_T present in the grain of plants which received foliar fertilization did not differ greatly from the amount present in the control plants that did not receive foliar fertilization (referring to only one plot). The greatest difference was observed in the amount of N_T present in the grains of plants from one plot compared to the grains of plants from the other plot; it could also be noted from the data of the analytical variation of the results, that the main absorption of foliar fertilizer took place between the time of fertilization and the first period of sampling (four weeks), the absorption in the following periods being almost insignificant (Fig. 8).

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Table 1

Results of the analysis of the different N fractions in pot experiments with maize plants as indicator
(Szarvas, 1979)

Treatment	Period of collection	N_T (%)	NH_4^+ (mg N/100 g)	NO_3^- (mg N/100 g)	Hydrolyzable (mg N/100 g)
Ø	1	0.14	0.4	1.0	2.3
	2	0.14	0.2	0.4	2.5
	3	0.13	0.2	0.3	2.2
	4	0.12	0.1	0.7	2.8
	5	0.13	0.1	0.7	2.0
PK	1	0.13	0.3	0.8	1.8
	2	0.14	0.2	0.4	1.6
	3	0.13	0.2	0.5	2.4
	4	0.09	0.1	1.0	2.4
	5	0.13	0.1	0.4	2.1
NPK	1	0.15	0.8	18.6	21.4
	2	0.14	0.2	9.5	9.0
	3	0.13	0.3	1.9	4.3
	4	0.13	0.1	2.8	5.1
	5	0.13	0.1	1.2	2.5

Periods of collection: 1. 15 June; 2. 5 July; 3. 1 August; 4. 22 August; 5. 4 September

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Table 2

Results of the analysis of the different N fractions in pot experiments with maize plants as indicator
(Szarvas, 1980)

Treatment	Period of collection	N_T (%)	NH_4^+—N (mg N/ 100 g)	NO_3^-—N (mg N/ 100 g)	Hydro-lyzable-N (mg N/100 g)
Ø	1	0.12	0.1	2.0	3.5
	2	0.13	0.1	0.7	1.6
	3	0.10	0.2	0.2	0.8
	4	0.14	0.1	0.7	1.6
	5	0.12	0.3	0.1	1.5
PK	1	0.12	0.1	0.8	2.5
	2	0.12	0.2	0.3	1.2
	3	0.10	0.2	0.5	1.0
	4	0.14	0.1	0.3	0.9
	5	0.12	0.3	0.1	1.8
$N_{0.5}$PK	1	0.12	0.1	19.4	20.9
	2	0.12	0.2	2.8	4.9
	3	0.09	0.3	1.2	2.0
	4	0.12	0.1	0.4	2.1
	5	0.12	0.3	0.3	1.6
$N_{1.0}$PK	1	0.13	0.7	49.3	52.4
	2	0.13	0.2	26.3	32.4
	3	0.11	0.4	7.5	8.8
	4	0.14	0.1	1.6	3.0
	5	0.13	0.4	0.2	2.6
$N_{1.5}$PK	1	0.14	2.0	58.7	76.6
	2	0.13	0.9	45.9	63.7
	3	0.11	1.1	47.1	57.0
	4	0.17	0.4	31.0	37.9
	5	0.13	0.6	15.9	18.9
$N_{2.0}$PK	1	0.15	7.0	62.2	101.7
	2	0.14	3.2	50.3	78.2
	3	0.09	2.4	56.8	84.9
	4	0.16	1.4	62.6	76.0
	5	0.13	1.3	43.7	60.0
$N_{2.5}$PK	1	0.17	10.1	71.1	131.0
	2	0.15	6.5	47.9	92.8
	3	0.15	6.8	59.0	100.9
	4	0.17	3.9	65.4	77.1
	5	0.15	2.6	47.4	71.6

Periods of collection: 1. 25 June; 2. 23 July; 3. 13 August; 4. 3 September; 5. 25 September

Table 3

Other N-fractions present in pot experiments with maize plants as indicator
(Szarvas, 1980)

Treatment	Period of collection	Easily hydrolyzable organic-N (mg N/100 g)	Non-hydrolyzable organic-N (mg N/100 g)
Ø	1	1.3	116.5
	2	0.8	128.4
	3	0.3	99.2
	4	0.8	138.4
	5	1.2	118.5
PK	1	1.6	117.5
	2	0.8	118.8
	3	0.4	99.0
	4	0.5	139.0
	5	1.5	118.2
$N_{0.5}PK$	1	1.3	99.1
	2	1.9	115.1
	3	0.7	88.0
	4	1.6	117.9
	5	1.1	118.4
$N_{1.0}PK$	1	2.5	77.6
	2	5.9	97.6
	3	0.9	101.2
	4	1.3	137.0
	5	2.0	127.4
$N_{1.5}PK$	1	16.0	63.4
	2	16.8	66.3
	3	8.7	53.0
	4	6.5	132.1
	5	2.4	111.1
$N_{2.0}PK$	1	32.6	48.3
	2	24.8	61.8
	3	25.8	5.1
	4	12.0	84.1
	5	14.9	70.0
$N_{2.5}PK$	1	49.8	39.0
	2	38.4	57.2
	3	35.2	49.1
	4	7.9	92.9
	5	21.6	78.4

Table 4

Results of the analysis of the rate of fertilizer-N present in each N-fraction
(Szarvas, 1980)

Treatment	Period of collection	^{14}N Original-N (mg N/100 g)	^{15}N Fertilizer-N (mg N/100 g)	^{14}N %	^{15}N %
$N_{1.5}PK$	1	121.1	18.9	86.5	13.5
	2	129.6	0.4	99.6	0.3
	3	109.6	0.4	99.6	0.4
	4	169.5	0.5	99.7	0.3
	5	128.8	1.2	99.1	0.9
$N_{2.0}PK$	1	149.5	0.5	99.7	0.3
	2	139.6	0.4	99.7	0.3
	3	77.0	13.0	85.6	14.4
	4	159.5	0.5	99.7	0.3
	5	129.6	0.4	99.7	0.3
$N_{1.5}PK$	1	1.99	0.01	99.5	0.5
	2	0.89	0.01	98.9	1.1
	3	1.09	0.01	99.1	0.9
	4	0.39	0.01	97.5	2.5
	5	0.59	0.01	98.3	1.7
$N_{2.0}PK$	1	6.98	0.02	99.7	0.3
	2	3.19	0.01	99.7	0.3
	3	2.38	0.02	99.2	0.8
	4	1.38	0.02	98.6	1.4
	5	1.29	0.01	99.2	0.8
$N_{1.5}PK$	1	11.0	47.7	18.7	81.3
	2	36.0	9.9	78.4	21.6
	3	46.9	0.2	99.6	0.4
	4	30.7	0.3	99.0	1.0
	5	13.9	2.0	87.4	12.6
$N_{2.0}PK$	1	61.2	1.0	98.4	1.6
	2	47.7	2.6	94.8	5.2
	3	10.7	46.2	18.7	81.3
	4	62.4	0.2	99.7	0.3
	5	40.5	3.2	92.7	7.3
$N_{1.5}PK$	1	76.1	0.5	99.3	0.7
	2	63.1	0.6	99.0	1.0
	3	7.9	49.1	13.8	86.2
	4	8.4	19.7	29.9	70.1
	5	4.3	14.6	22.8	77.2
$N_{2.0}PK$	1	101.1	0.6	99.4	0.6
	2	77.2	1.0	98.7	1.3
	3	12.9	72.0	15.2	84.8
	4	10.3	65.7	13.6	86.4
	5	6.6	53.4	11.0	89.0

Table 5

Results of the analysis of hydrolyzable-N within the 10–20 cm horizon of a soil profile (Agárd, 1979)

Period	Plot	Plot	Plot
	mg N/100 g		
1. March 21.	3.2	4.1	2.8
2. April 4.	4.0	4.1	3.8
3. April 17.	3.8	3.9	3.1
4. April 27.	3.5	4.6	3.7
5. May 11.	5.2	3.9	6.0
6. May 28.	6.0	4.4	3.4
7. June 13.	5.0	2.5	3.5
8. June 26.	2.8	2.7	3.3
9. July 10.	2.7	2.6	1.6
10. July 27.	1.3	2.3	2.3
11. August 7.	2.4	2.5	1.8
12. August 22.	2.6	2.4	2.4
13. September 4.	1.9	2.5	2.5
14. September 20.	2.1	1.4	2.5
15. October 3.	2.5	1.4	2.6

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EFFECT OF NITROGEN FERTILIZER ON YIELD COMPONENTS OF DIFFERENT MUTANTS OF RICE (ORYZA SATIVA L.)

The effects of N fertilizer on the yield and yield components of twelve induced mutants of rice, var. Latisail, were studied on a clay loam soil. Increased levels of N resulted in an increase in yield components, thereby increasing the grain yield. Significant genotypic differences due to N fertilization were observed for characters such as heading duration, plant height, tillers/plant, length of panicle, grains/panicle and yield/plant.

The induction of desirable plant types responsive to high fertility has been possible in cereals. Mention can be made of the induced plant types for high fertilizer responsiveness in barley and rice (GUSTAFSSON 1954, HU *et al.* 1960, LI *et al.* 1962). Thus, plant type has been considered as one of the most important criteria with regard to the varietal response to nitrogen (BEACHELL—JENNINGS 1965, TANAKA *et al.* 1966). The modification of the plant type through mutation for a varietal improvement in fertilizer response has become an important field of research in plant breeding.

The present investigation aimed to assess the N fertilizer assimilation potential which improves the yield components and grain yield of different induced agronomical mutants of rice.

The induced stable mutants of the Latisail cultivar of rice (*Oryza sativa* L.) were subjected to different doses of nitrogen fertilizer in a randomized block design using 3 replications at the Burdwan University Crop Research Farm. The soil of the experimental field was clay loam. Five levels of N (0, 50, 100, 150 and 200 kg/ha) were applied in the form of urea in two doses: half was applied as a basal dose and the other half as top dressing 25 days after transplantation when the plants were in the actively tillering stage. The P, in the form of superphosphate (single), and K in the form of muriate of potash were applied as basal doses at the rate of 150 and 75 kg/ha, respectively. Each plot measured 7.93 m^2 and consisted of 150 plants transplanted in 10 rows, the spacing being 23×23 cm. At the pre- and post-harvest stages, observations were recorded for 10 randomly selected plants per plot for the characters mentioned in Table 1. The data were statistically analysed by analysis of variance per character, taking replication, genotypes (G), nitrogen level (N), $G \times N$, and error as the sources of variance. The "F" and "CD" values for genotypes, nitrogen levels and their interaction were compared at the $P = 0.05$ level.

The effect of different levels of N on the expression of yield and its components in both the control and the induced agronomical mutants of Latisail are presented in Table 1. It has been observed that heading time was significantly delayed due to N application. The *Indica* variety of rice utilizes the absorbed nitrogen to produce luxuriant vegetative growth (MUKHERJEE—SIRCAR 1968), and flowering was thus delayed after N fertilization. An increase in the level of N was reflected significantly in the production of more yield and in the individual yield components (plant height, number of effective tillers per plant, length of panicle and grains per panicle) in the mutants. Plant height significantly increased due to N application. WOODWARD (1966), SIRAJUDDIN—AHMED (1967) and MALLICK—GHOSH HAJRA (1978), among others, observed similar responses.

An increase in the level of N was reflected in the production of more tillers compared to the unfertilized condition, a result similar to those found by GARG—TOMARIA (1970), BLACK (1970) and MALLICK *et al.* (1978).

Increased rates of N up to 200 kg/ha resulted in an increase in panicle length and the number of grains per panicle in the induced mutants, which is in conformity with the results of PRASAD—SHARMA (1973), SIRAJUDDIN—AHMED (1967) and MALLICK—GHOSH HAJRA (1978).

The grain yield per plant also increased significantly with an increase in N dose. ASHLEY *et al.* (1965), KALJU—HANWAY (1966), SHARMA—SHRIVASTAVA (1971) reported increased yields. The elevated yield after N application was found to be due to an improvement in yield components. The nitrogen level influences grain yield through the determination of yield capacity, where the straw : grain ratio should be high and the proportion of ripened grains high at a high N level (YOSHIDA 1972). The mutants Tall and Awned were higher yielders than the *Indica* parent. Various reports (BOROJEVIĆ—BOROJEVIĆ 1972, FUTSUHARA *et al.* 1967) indicated that the yield is higher in short-statured mutants of cereals as compared to the tall varieties. But in contrast to the above, induced dwarf mutants were very inferior in yield to their parents. This was found to be due to a significant reduction in the yield components.

The mutant strains were found to be responsive to increased levels of N for promoting the yield components contributing to higher yield. It has been suggested that selection for yield and nitrogen responsiveness may be possible through indirect selection on the basis of plant type, and thus plant type has been considered an important criterion with regard to

Table 1

Mean yield components and yield per plant in the control (Latisail) and different induced mutants at five levels of nitrogen

Genotype	Nitrogen dose (kg/ha)					Mean
	N_0	N_{50}	N_{100}	N_{150}	N_{200}	
	(a) *Heading duration* (days)					
Control	119.4	124.1	126.7	130.0	134.3	126.9
1	124.8	130.0	134.7	137.5	138.8	133.1
2	120.9	125.6	129.9	130.0	136.0	128.4
3	119.6	125.1	129.7	134.0	135.8	128.8
4	119.6	125.8	132.0	135.0	136.6	129.8
5	118.5	123.0	130.8	134.1	136.1	128.5
6	115.8	122.3	130.9	135.2	137.5	128.3
7	119.6	126.2	131.6	136.0	137.5	130.1
8	116.1	122.1	131.0	134.0	136.3	127.9
9	90.6	97.9	105.1	108.4	113.0	103.0
10	129.7	135.5	144.2	147.0	149.1	141 1
11	113.5	120.6	126.9	132.3	136.3	125.9
12	126.7	135.0	142.0	147.1	148.0	139.7
Mean	118.0	124.0	130.4	133.8	136.5	
	(b) *Plant height* (cm)					
Control	104.1	111.4	115.7	118.5	123.0	114.5
1	51.6	56.1	60.6	63.7	69.2	60.2
2	126.0	131.8	135.7	140.4	143.0	135.3
3	111.7	119.0	122.3	126.7	131.3	122.2
4	112.5	117.7	121.5	127.3	129.7	121.7
5	65.6	70.7	75.1	79.3	83.6	74.8
6	115.9	120.1	129.2	133.5	140.2	127.7
7	70.9	77.4	83.8	87.9	92.1	82.4
8	56.0	61.0	64.0	71.3	73.5	65.1
9	105.0	111.1	116.0	119.8	124.9	115.3
10	65.6	72.4	77.7	80.6	84.0	76.0
11	79.9	85.6	91.6	98.5	103.6	91.8
12	138.1	144.0	150.6	153.2	157.3	148.6
Mean	92.5	98.3	103.3	107.7	111.9	

(a) F value for G mean = 1081.828^{++} $CD_{5\%}$ for G mean = 0.076
F value for N mean = 1982.815^{++} $CD_{5\%}$ for N mean = 0.047
F value for G×N = 5.824^{++} $CD_{5\%}$ for G×N = 1.712

(b) F value for G mean = 7810.174^{++} $CD_{5\%}$ for G mean = 0.091
F value for N mean = 1415.136^{++} $CD_{5\%}$ for N mean = 0.056
F value for G×N = 4.156^{++} $CD_{5\%}$ for G×N = 2.050

Table 1 (continued)

Genotype	Nitrogen dose (kg/ha)					Mean
	N_0	N_{50}	N_{100}	N_{150}	N_{200}	
	(c) *Tillers per plant* (No.)					
Control	12.3	15.4	18.9	20.6	23.2	18.0
1	134.2	142.2	157.4	168.1	175.0	155.3
2	12.9	15.6	21.4	25.2	29.4	20.9
3	12.7	17.7	22.0	26.1	28.8	21.4
4	15.0	21.3	26.2	30.8	35.0	25.6
5	14.7	21.4	27.1	34.2	37.4	26.9
6	13.0	17.1	21.9	29.7	35.4	23.4
7	8.6	10.5	15.2	20.4	22.8	15.5
8	4.9	6.1	9.7	11.4	14.6	9.3
9	11.0	15.6	20.0	25.1	28.0	19.9
10	7.4	10.3	14.8	17.4	19.8	13.9
11	9.1	13.3	21.0	26.0	29.7	19.8
12	4.2	5.5	7.1	9.7	11.3	7.5
Mean	20.0	24.0	29.4	34.2	37.7	
	(d) *Length of panicle* (cm)					
Control	10.3	17.6	23.5	27.8	30.9	22.0
1	6.2	6.9	7.6	8.2	8.7	7.5
2	19.0	22.8	26.9	30.2	32.4	26.2
3	10.0	12.9	16.9	20.5	22.7	16.6
4	16.0	18.8	22.1	26.5	28.7	22.4
5	10.4	14.5	16.0	19.4	21.0	16.2
6	12.5	18.4	21.7	24.6	26.5	20.7
7	13.4	17.4	20.7	23.7	25.6	20.1
8	9.9	14.5	16.9	20.4	22.6	16.8
9	12.5	18.9	21.1	24.7	26.2	20.6
10	9.9	13.3	16.3	19.5	21.6	16.1
11	12.4	18.0	20.1	23.4	25.2	19.8
12	18.0	21.7	26.8	29.7	31.3	25.5
Mean	12.3	16.5	19.7	22.9	24.8	

(c) F value for G mean = 18 083.430^{++} $CD_{5\%}$ for G mean = 0.079
F value for N mean = 1670.633^{++} $CD_{5\%}$ for N mean = 0.049
F value for G×N = 32.397^{++} $CD_{5\%}$ for G×N = 1.785

(d) F value for G mean = 1848.005^{++} $CD_{5\%}$ for G mean = 0.031
F value for N mean = 5200.561^{++} $CD_{5\%}$ for N mean = 0.019
F value for G×N = 40.772^{++} $CD_{5\%}$ for G×N = 0.070

Table 1 (continued)

Genotype	Nitrogen dose (kg/ha)					Mean
	N_0	N_{50}	N_{100}	N_{150}	N_{200}	
	(e) *Grains per panicle No.*					
Control	101.7	110.2	123.1	135.5	141.2	122.3
1	8.4	11.4	15.7	18.9	24.6	15.8
2	133.6	147.0	159.3	172.3	182.5	158.9
3	73.9	80.9	90.0	94.8	101.9	88.3
4	97.6	105.1	115.4	125.7	132.9	115.3
5	33.4	41.0	47.1	57.8	62.6	48.3
6	109.3	118.7	129.4	138.8	145.8	128.4
7	51.8	61.5	68.3	77.7	84.8	68.8
8	79.9	89.2	96.4	109.7	116.3	98.3
9	79.3	89.2	99.5	112.5	118.4	99.7
10	47.5	55.2	63.0	72.5	80.5	63.7
11	78.1	85.1	92.4	103.3	111.1	94.0
12	78.4	84.9	93.2	101.0	108.6	93.2
Mean	74.8	83.0	91.7	101.5	108.5	
	(f) *Yield per plant* (g)					
Control	23.4	28.7	34.3	36.2	34.6	31.4
1	12.5	16.4	22.3	25.6	27.4	20.8
2	30.8	36.5	43.1	46.2	45.3	40.3
3	16.9	19.4	26.3	31.1	33.9	25.5
4	7.8	8.7	9.6	10.7	11.0	9.5
5	6.0	6.7	7.5	8.3	8.7	7.4
6	29.5	35.2	41.3	44.2	43.6	38.7
7	8.2	10.3	14.8	17.9	19.4	14.1
8	6.9	8.1	8.8	9.8	10.3	8.7
9	20.6	25.7	33.0	39.5	43.7	32.5
10	8.7	10.3	13.9	16.7	19.1	13.7
11	16.2	21.7	28.7	34.8	40.0	28.2
12	1.6	1.9	2.0	2.2	2.4	2.0
Mean	14.5	17.6	21.9	24.8	26.1	

(e) F value for G mean = $14\,099.640^{++}$ $CD_{5\%}$ for G mean = 0.087
F value for N mean = 4952.691^{++} $CD_{5\%}$ for N mean = 0.054
F value for G×N = 21.983^{++} $CD_{5\%}$ for G×N = 1.949

(f) F value for G mean = 3601.743^{++} $CD_{5\%}$ for G mean = 0.077
F value for N mean = 884.721^{++} $CD_{5\%}$ for N mean = 0.048
F value for G×N = 32.744^{++} $CD_{5\%}$ for G×N = 1.731

1 = Grassy; 2 = Tall; 3 = Round grain; 4 = Abnormal panicle; 5 = Semi-dwarf; 6 = Awned; 7 = Boat leaf; 8 = Extreme dwarf; 9 = Early heading; 10 = Late heading; 11 = Scattered tiller and 12 = Flat grain.

$^{++}$, $^{+}$ Significant at P = 0.01 and 0.05, respectively; G = Genotype; N = Nitrogen levels.

varietal response to nitrogen (BEACHELL—JENNINGS 1965, TANAKA *et al.* 1966). The mutational rectification of the plant type for the improvement of rice varieties in respect of fertilizer response shows great potential.

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ALLELOPATHY OF SORGUM HALEPENSE (L.) PERS. ON WEEDS AND CROPS

The allelopathy of *Sorgum halepense* (L.) Pers. was studied on *Amaranthus retroflexus* L. and maize. The *Amaranthus retroflexus* seeds were germinated on slices of Johnson-grass rhizomes and on rhizome extracts of different concentrations. The germination of *Amaranthus retroflexus* on slices of Johnson-grass rhizomes was retarded and the germination percentage was reduced. The germination of *Amaranthus retroflexus* was also inhibited by extracts prepared from Johnson-grass rhizomes as a function of the extract concentrations. Growth disorders and seedling deformations were also observed in *Amaranthus retroflexus* due to rhizome extracts. The growth of maize seedlings was considerably inhibited by the Johnson-grass extracts.

Rhizome extracts had only a slight effect on maize roots but a stronger effect on the shoots. As extract concentrations decreased the inhibitory effects also decreased; nevertheless, the growth and dry matter weight of maize shoots were reduced slightly even at the minimum extract concentration.

Over the last 50 years there have been many discussions about allelopathy (WHITHNEY—CAMERON 1904, PRJANISCHNIKOW 1930, MOLISCH 1937, GRÜMMER—BEYER 1959, BÖRNER 1959, RADEMACHER 1959, GRESSEL—HOLM 1964, LAURENCE—KING 1966, KOCH 1969). Nowadays most workers accept its existence and effects. Most of the experiments recently carried out on allelopathy used *Agropyron repens* (L.) Beauv. (OSVALD 1947, HAMILTON—BUCHHOLTZ 1955, KOMMEDAHL *et al.* 1959, PROBST 1970, HESS 1978). PROBST (1970) could not detect any effect of the decaying parts or the decomposition products of this species on crops. However, according to HESS (1978), it is important to investigate whether *Agropyron repens* rhizomes destroyed by glyphosate treatment have any effects on other plants.

On observing the weed flora of maize fields with heavy Johnson-grass infestation, in most cases only Johnson-grass plants were found in spite of the fact that the results of weed seed content examinations in the soil indicated that the cultivated layer of the soil examined was mainly contaminated by seeds of *Amaranthus retroflexus* (SZOLNOKY 1972). Due to the effect of treatment with glyphosate in September, Johnson-grass plants from rhizomes were destroyed and by spring the plant residues had decayed. In spring, when the weed flora of the treated field was re-recorded, the cover of *Amaranthus retroflexus* appeared to be more than 90%; no Johnson-grass plants from rhizomes were found and there were only a few seedlings present (MIKULÁS 1976). These results, together with the literature, suggested that besides competition other factors may be involved in the rapid spreading of Johnson-grass infestions (RICE 1974).

Thus, it was considered important to investigate the allelopathy of Johnson-grass in connection with *Amaranthus retroflexus* and maize.

The effects on Johnson-grass rhizomes and rhizome extracts on the germination of *Amaranthus retroflexus* and their effects on maize growth in a hydroculture were studied. The studies were conducted in the laboratory of the Institut für Phytomedizin, Stuttgart University, FRG. In the experiments Johnson-grass rhizomes collected in Hungary were used. *Amaranthus retroflexus* seeds were germinated in Petri dishes containing rhizome slices

of about 1.5 g. Extracts of Johnson-grass rhizomes were prepared as follows: 200 g of rhizomes were cut into small fragments and boiled for 5 minutes in distilled water. This was allowed to cool for half an hour, after which it was filtered in a Büchner funnel through filter paper. The filtrate was made up to 2000 ml with distilled water. The Hoagland nutrient solution was diluted in a 1 : 1 ratio with distilled water. The supplying solution contained 120 ml of nutrient solution and 880 ml of distilled water per litre. Table 1 shows the extracts and the quantities of nutrient solution applied to the Neubauer plates according to the treatments. For the germination tests 1, 2, 4 or 8 ml Johnson-grass extract were pipetted into Petri dishes, then each of them was made up to 8 ml with distilled water. The control Petri dishes

Table 1

Quantities of extract, nutrient solution and distilled water used in the hydroculture experiment

Treatment	Extract	Nutrient solution	Distilled water
K_1	188	75	187
K_2	94	75	281
K_3	47	75	328
K_4	23.5	75	351.5
Control	0	75	375

were filled with 8 ml of distilled water. Absorbent papers were put in all Petri dishes, containing both rhizome slices and extracts, after which 100 seeds of *Amaranthus retroflexus* were sown in each of them. The dishes sown with seeds were placed to germinate in the dark in a thermostat set at 25 °C. Germination was registered every day at the same time. This experiment was designed in four replications and took 21 days. For the hydroculture experiment maize plants of the Limac variety were used. Three seedlings of maize with about 5 cm shoots and roots were planted in each Neubauer plate and the plates were placed in a tropical greenhouse. To compensate moisture loss during the germination test the supplying solution described above was used. Plant height was measured daily. This experiment took 10 days, with five replications. The maize shoots and roots were dried at 105 °C in an oven and their dry matter weights determined.

The germination of *Amaranthus retroflexus* is shown in Fig. 1. The speed of germination in the control Petri dishes was greater than that in Petri dishes containing rhizome slices. The final percentage of germination on the 7th day was 95%. In Petri dishes containing rhizome

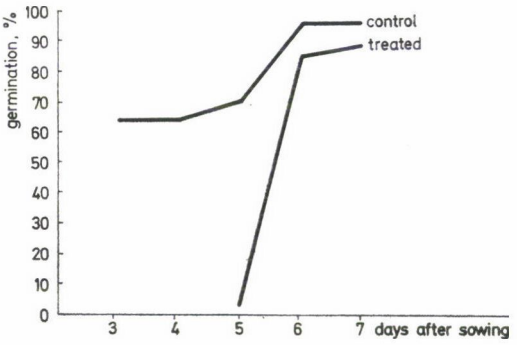

Fig. 1. Germination of *Amaranthus retroflexus* L. on *Sorgum halepense* rhizome slices

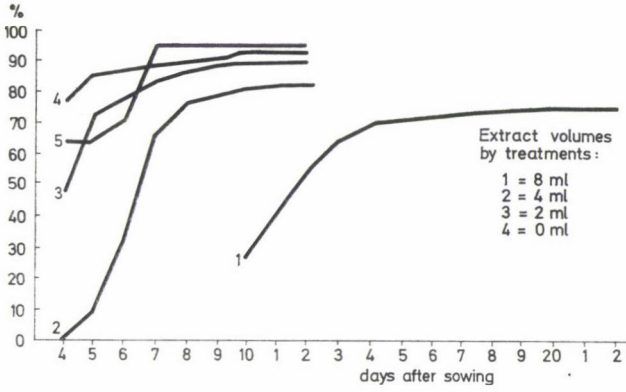

Fig. 2. Germination dynamics of *Amaranthus retroflexus* L. in different quantities of *Sorgum halepense* rhizome extract

slices germination started on the 5th day and by the 7th day reached a percentage of germination 7% less than that of the control.

As shown in Figs 2 and 3, the germination dynamics and percentages of *Amaranthus retroflexus* seeds varied according to the concentrations of Johnson-grass rhizome extracts. In a hydroculture the weight increase of the maize shoots and roots was significantly retarded by Johnson-grass rhizome extract (see Fig. 4).

The average weights of maize plants decreased as a function of the extract concentration. The daily plant growth is shown in Fig. 5. An increase in concentration caused a reduction in plant height.

Both Johnson-grass rhizomes and the extracts prepared from rhizomes reduced and retarded the germination of *Amaranthus retroflexus*. Both the reduction in the percentage and the retarding of germination gave good evidence of the allelopathic effects of Johnson grass plants from rhizomes. Further evidence was provided by the fact that most of the seedlings emerging from dishes treated with rhizomes or rhizome extract were strongly deformed and twisted. Healthy plants cannot develop from such seedlings. The maximum decrease and retardation in the germination of *Amaranthus retroflexus* seeds was observed when 8 ml of the rhizome extract was applied. In a hydroculture Johnson-grass rhizome extracts only slightly inhibited the growth of the maize root system, but strongly inhibited that of the shoots. A reduction in the concentration considerably decreased the inhibitory effect. At greater extract concentrations maize growth practically ceased. The results showed

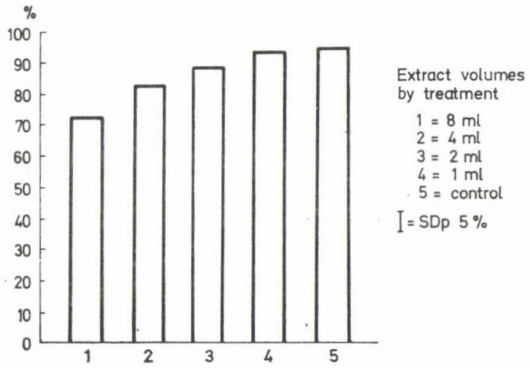

Fig. 3. Germination of *Amaranthus retroflexus* L. in different quantities of *Sorgum halepense* rhizome extract

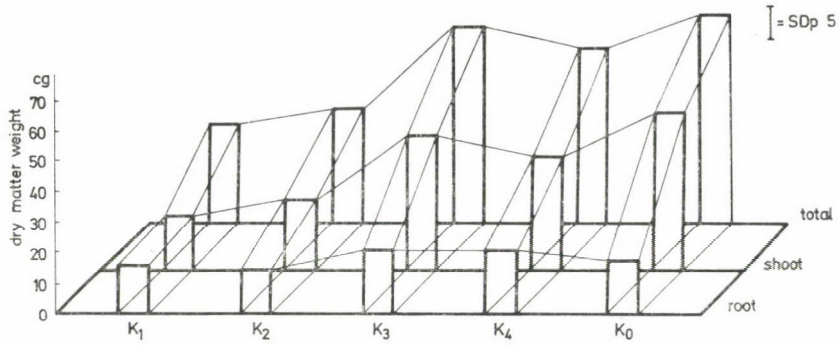

Fig. 4. Weight of maize seedlings as affected by different quantities of *Sorgum halepense* rhizome extract

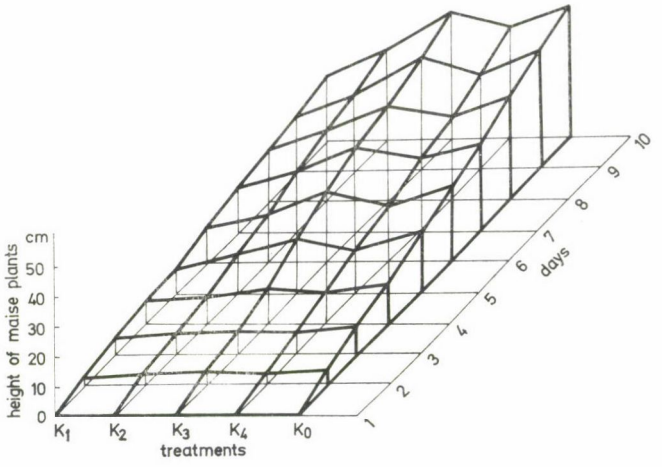

Fig. 5. Maize growth in a hydroculture as affected by different quantities of *Sorgum halepense* rhizome extract

that the growth of maize might be affected negatively by insignificant quantities of Johnson-grass rhizome extract, i.e. a minimal infection of Johnson-grass in the field could induce a temporary reduction in the growth of maize.

The rapid spreading and dominance of Johnson-grass can be attributed to the inhibitory compounds present in the rhizomes. The homogeneous cover of Johnson-grass in fields where soils are heavily infected with seeds of other weed species can be explained by its allelopathic effects. No further inhibitory effects could be observed after the decay of the rhizomes, as reported also by FRIEDMAN—HOROWITZ (1970). Due to the disappearance of the inhibitory effect, *Amaranthus retroflexus* seeds were able to germinate in an enormous quantity.

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EFFECT OF DRYING TEMPERATURE ON THE PROTEIN QUALITY OF GRAIN MAIZE

Provided the proper cultural practices are applied, the yield averages for the maize hybrids grown in Hungary show an ever increasing tendency, so in a relatively short period enormous volumes are harvested. The moisture content of maize when harvested is generally 25–30%, though in years with unfavourable weather conditions it may be as much as 40%. However, at such a high moisture content it cannot be stored, which is why maize drying facilities operated using various technologies have been established all over the country.

The driers consume a great deal of energy so they must be utilized as economically as possible. The correct choice of drying temperature and drying time are thus important from the point of view of the national economy. If these parameters are not properly chosen, apart from the waste of energy, the maize grains will be damaged to such an extent that their feeding value will be lowered and the percentage of broken grains greatly increased (KÓTA—HARASZTI 1977).

The protein content of the maize grain is relatively low; yet, if the volume of yield and the biological value of the grain are taken into consideration, it is nevertheless of great importance. Hungary covers a large proportion of its feed protein requirements from imports; it is therefore extremely important to preserve the protein content of the maize grain with the least possible damage in the course of drying. As reported by ERBERSDOBLER (1969), ERBERSDOBLER *et al.* (1969), HUSS (1978), RIVERS *et al.* (1978) and KÜTHER (1979), as a consequence of heat treatment the proteins become denaturized, some amino acids, lysine in particular, decompose or enter into reaction with carbohydrate molecules through their ε-amino groups, whereby the biological value of the protein will be reduced and the absorption of amino acids deficient. Lysine is a limiting amino acid of primary importance for pigs; it is therefore imperative to preserve the amount contained in the maize grain without losses.

Little is known of the effect of the drying conditions and the drying temperature on the proteins of maize varieties with different moisture contents and nutritive values, so the present study was aimed at obtaining data leading to a correct choice of temperature.

In 1978 and 1979 the varieties SC 3385, MV 580, MV 429, SC 3365, SC 369 and SC 256 were dried at 60, 80, 90, 110 and 130 °C in the laboratory drier of the Storage and Material Handling Section of the Research Institute for the Milling and Baking Industry, while the varieties PX 20, JX 62, JX 92 and H 404 were dried at 80, 100 and 120 °C in the B-15 type driers of the Bábolna Maize Production System.

The characteristics of the laboratory drier, together with the technologies applied, were described in detail by JUHÁSZ *et al.* (1979). As a criterion of the drying temperature, the nutrient contents of the samples were determined by chemical analyses on the basis of the MSZ 68–30 standard (ANONYMOUS 1966). The amino acid (AS) composition of the maize hybrids was determined with a BC-200 amino acid analyser. The available lysine content was measured by the method described by CARPENTER (1960) and CARPENTER—BOOTH (1973). The biological tests were performed on male albino rats.

On the basis of N turnover examinations the biological value (BV), net protein utilization (NPU) and productive protein utilization (PPU) of the maize proteins were determined (SZELÉNYI-GALÁNTAI 1969). At the end of the experiments blood was taken from the animals and the total amino acid-nitrogen (AA-N) content was measured with chemical methods (BÁLINT 1962). The digestive system of the rat converts feed in a similar way to that of pigs, so rats can be used to replace the extremely expensive, lengthy pig experiments.

It was found in the experiments that the temperature applied when drying maize grains did not influence the nutrient contents (crude protein, crude fat, crude fibre, crude ash, nitrogen-free extract) of the varieties. There were, however, substantial differences between the varieties as regards the amount of crude protein. The highest percentage of crude protein (11%) was found in the opaque maize SC 3385, while PX 20 contained as little as 8.1% crude protein. The crude fat content ranged from 3.5 to 4.4% in the different varieties, but the opaque maizes examined contained 0.5–1.0% more crude fat, though a higher oil content is not generally characteristic of the opaque varieties. The differences between the varieties in crude ash and crude fibre were negligible.

The amino acid composition of proteins in the different maize varieties as a percentage of the dry matter content is summed up in Table 1. According to our investigations the most characteristic feature of the opaque maizes is the almost double quantity of total lysine (0.37–0.45%) compared to other maize varieties (0.22–0.26%). The methionine content in the varieties examined ranged between 0.13 and 0.22%, and the cistine contents between 0.14 and 0.25%. The maize proteins are relatively rich in arginine (0.43% on average), while the threonine content shows an average value of 0.37%. Another characteristic feature is the 1 : 3.5 ratio of isoleucine to leucine. (This ratio is 1 : 2 for barley, Triticale, rye and oats, 1 : 10 for bloodmeal and 1 : 1.5 for yeast.)

According to the results of amino acid analyses, the amino acid composition of maize grown in different years and of different varieties, and used in the drying experiments, was only slightly changed by the 110 °C drying temperature. The higher temperature (130 °C) caused a 5–8% reduction in basic and sulphur-containing amino acids. In 1978 the moisture content of the samples before drying was 28–30%.

Of the basic amino acids, lysine, available lysine, and the parameters relevant to protein conversion, are presented in tables as a function of the year, the drying system and the temperature.

The results obtained with the laboratory drier in 1978 are contained in Table 2. The effect of drying at 60–90 °C and 130 °C was traced on one opaque and two normal hybrids. The crude protein and lysine contents were not affected to any great extent by the drying temperature. For the other parameters, however, particularly in opaque SC 3385, drying at 130 °C caused a substantial reduction. The available lysine content fell from 81 to 76%, the

Table 1

Amino acid composition of samples used in maize drying experiments in 1978 and 1979, expressed as percentage of dry matter

Amino acid	Variety										
	SC 3385	MV 580	MV 429	PX 20	JX 62	JX 92	H 404	SC 3365	MV 580	SC 369	SC 256
	1978			1979							
Aspartic acid	1.00	0.80	0.66	0.47	0.44	0.58	0.95	0.94	0.76	0.61	0.62
Threonine	0.47	0.39	0.35	0.39	0.28	0.41	0.38	0.39	0.37	0.28	0.33
Serine	0.49	0.70	0.69	0.46	0.49	0.48	0.52	0.55	0.59	0.43	0.46
Glutamic acid	2.40	2.90	2.40	2.09	1.63	1.92	2.49	1.81	2.22	2.01	1.90
Proline	1.12	0.96	0.95	0.81	1.11	0.64	1.27	0.94	0.87	0.62	0.73
Glycine	0.48	0.40	0.34	0.39	0.30	0.31	0.34	0.52	0.39	0.31	0.37
Alanine	0.82	0.72	0.66	0.63	0.63	0.81	0.84	0.73	0.64	0.69	0.75
Cistine	0.22	0.19	0.19	0.19	0.18	0.16	0.14	0.25	0.18	0.18	0.18
Valine	0.76	0.59	0.57	0.44	0.36	0.36	0.53	0.64	0.48	0.44	0.38
Methionine	0.22	0.21	0.20	0.17	0.15	0.13	0.16	0.13	0.19	0.18	0.17
Isoleucine	0.40	0.34	0.31	0.39	0.27	0.24	0.36	0.34	0.30	0.31	0.29
Leucine	1.35	1.36	1.29	1.04	1.00	1.11	1.39	0.94	1.20	1.22	1.22
Tyrosine	0.41	0.37	0.39	0.35	0.27	0.30	0.38	0.27	0.33	0.34	0.34
Phenylalanine	0.56	0.53	0.50	0.41	0.43	0.45	0.61	0.46	0.46	0.41	0.47
Lysine	0.45	0.29	0.22	0.23	0.26	0.23	0.23	0.37	0.26	0.25	0.25
Histidine	0.33	0.28	0.23	0.22	0.24	0.23	0.23	0.29	0.26	0.22	0.26
Arginine	0.59	0.44	0.37	0.37	0.38	0.33	0.34	0.64	0.47	0.33	0.40

Table 2

Percentage changes in the parameters of maize grains dried under laboratory conditions in 1978, in response to various drying temperatures

	Opaque SC 3385		MV 580		MV 429	
	60–90	130	60–90	130	60–90	130
	°C					
Crude protein content, %	11.0	11.0	10.4	10.4	10.0	10.0
Lysine content as a percentage of dry matter	0.45	0.42	0.29	0.28	0.22	0.21
Available lysine, %	81	76	83	80	80	75
Biological value	77	67	72	70	74	70
Net protein utilization	75	66	68	66	70	66
Productive protein utilization	49	36	44	40	40	34

BV from 77 to 67%, the NPU from 75 to 66% and the PPU from 49 to 36%. In two other hybrids examined subsequently the 130 °C drying temperature caused a lower (some 5–8%) reduction in these values. In both MV 580 and MV 429 the PPU showed the most pronounced reduction in response to the higher temperature.

In maize samples dried in 1979 the moisture content was 22–24% on average, some one-fifth less than in the previous year, which made it possible to shorten the period of drying. As a consequence, the results of both large-scale and laboratory drying were much more favourable.

Table 3 contains the results of large-scale drying in 1979. That year only normal hybrids were examined under large-scale conditions (PX 20, JX 92, JX 62 and H 404). The crude protein content was 8.1–9.4% and the lysine content 0.22–0.26%. The available lysine content was 82–85% at a drying temperature of 80 °C and fell to 76–84% when the drying temperature was raised to 120 °C. The biological value averaged 68%, and only that of H 404 fell to 64% at a drying temperature of 120 °C.

In 1979 the moisture content of opaque and other maize hybrids dried under laboratory conditions was 22–24% before drying. The crude protein content of the samples ranged from 8.8 to 10.1%. The opaque maize contained 0.37% and the other hybrids an average of 0.25% lysine. The available lysine content was generally 72–84% and only decreased by 6% in opaque maize when dried at 130 °C. The biological value was 80% in opaque maize SC 3365 and an average of 71% in the other hybrids; it was only in SC 256 that it showed any considerable decrease (to 56%) in response to drying at 130 °C.

Figure 1 shows the total amino acid-nitrogen (AA-N) content of the blood in animals fed with maize grown in different years and dried at various temperatures. The value of total AA-N content in blood samples taken at the same time after feeding is a good indication of the damage caused by heat. The figure clearly indicates that high temperature resulted in a considerable (some 30–40%) loss in 1978, but only half as much (15–20%) in 1979.

On the basis of the results obtained so far it can be concluded that drying maize at a temperature of up to 90 °C did not cause any loss in the amino acid content, including the lysine content, of the grain. It follows that BV, NPU and PPU did not change either.

Temperatures above 100 °C did not significantly affect the crude nutrient and amino acid contents of the samples.

The longer period of drying at 130 °C in 1978 resulted in an average reduction of 15% in the available lysine contents and protein conversion values of opaque maizes with higher

Table 3

Percentage changes in the parameters of maize dried under large-scale conditions in 1979, in response to various drying temperatures

	PX 20			JX 62			JX 92			H 404		
	80	100	120	80	100	120	80	100	120	80	100	120
	°C											
Crude protein content, %	8.1	8.1	8.1	9.4	9.4	9.4	8.7	8.7	8.7	9.1	9.1	9.1
Lysine content as a percentage of dry matter	0.23	0.23	0.23	0.26	0.25	0.23	0.23	0.22	0.22	0.23	0.22	0.23
Available lysine, %	85	85	84	84	85	80	85	79	79	82	81	76
Biological value %	70	69	70	66	66	68	68	66	67	71	70	64
Net protein utilization %	65	63	68	60	61	64	66	63	65	68	69	62
Productive protein utilization %	28	29	36	32	34	37	34	31	33	41	39	34

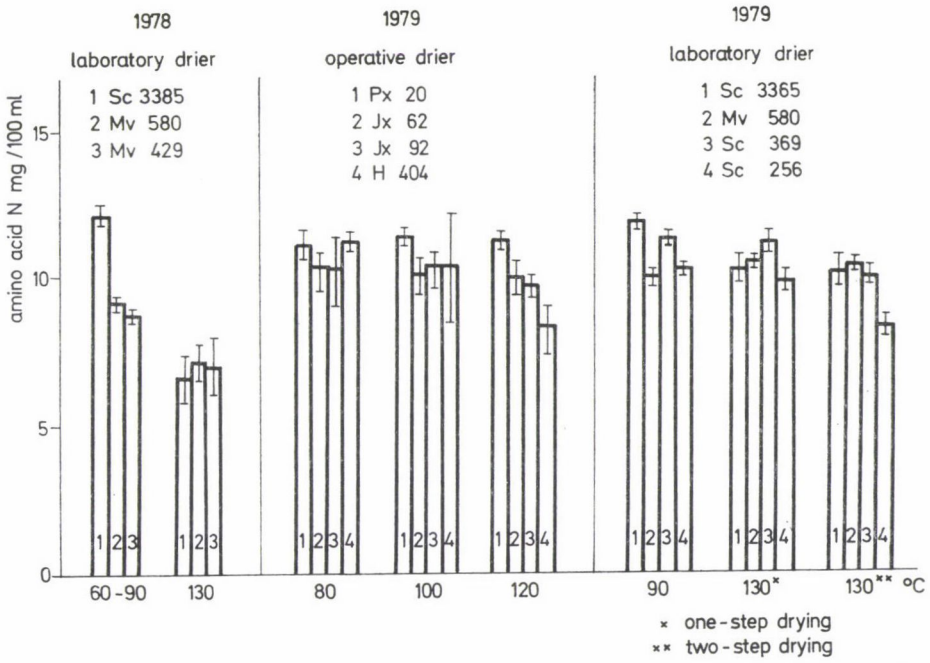

Fig. 1. Changes in the total amino acid-N content of the blood in rats fed with maize dried at various temperatures

Table 4

Percentage changes in the parameters of maize dried under laboratory conditions in 1979, in response to various drying temperatures

	SC 3365 Opaque			MV 580			SC 369			SC 256		
	90	130*	130**	90	130*	130**	90	130*	130**	90	130*	130**
	°C											
Crude protein content, %	10.1	10.1	10.1	9.2	9.2	9.2	8.8	8.8	8.8	9.5	9.5	9.5
Lysine content as percentage of dry matter	0.37	0.37	0.37	0.26	0.25	0.26	0.25	0.25	0.25	0.25	0.25	0.25
Available lysine, %	84	80	79	79	78	79	81	79	80	79	77	78
Biological value %	80	78	79	72	77	77	70	69	67	70	66	59
Net protein utilization %	77	75	76	71	76	75	66	64	62	67	63	56
Productive protein utilization %	48	46	46	42	49	48	38	34	32	39	33	26

* One-step drying
** Two-step drying

lysine contents, and in a 40% loss in the total amino acid-N content of the blood. In the case of other hybrids the same period and temperature of drying caused only half as much loss in these parameters.

Due to the lower moisture content, in 1979 the maize could be dried with a relatively low reduction in value (less than 10% on average) both under laboratory and large-scale conditions (Table 4).

On the basis of the experimental data a value of 0.83 was established for the coefficient of correlation between available lysine content and PPU, and a value of 0.55 for the coefficient of correlation between available lysine content and BV.

These experimental methods, the scope of which is intended to be widened, are considered to be suitable for demonstrating damage caused by the drying temperature, improvement of drying technologies may be greatly promoted by the above indices of value.

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SEROGROUPING OF RHIZOBIUM LEGUMINOSARUM STRAINS ISOLATED FROM DIFFERENT SOILS

Rhizobia lend themselves to various serological techniques which provide information regarding their taxonomy and strain identification (VINCENT 1941, BROCKWELL—DUDMAN 1968). The use of strain-specific somatic antigens has been reported in many *Rhizobium* species for the identification of the inoculant strain in competition with native rhizobia in the soil (BROCKWELL—DUDMAN 1968, DOROSINKII—MAKAROVA 1977, CHAHAL *et al.* 1978). Little

information is available on the antigenic relationship among the strains of *Rhizobium leguminosarum* occurring naturally under different agro-climatic conditions. The present paper describes an attempt to study the competitiveness and serological relationship of different strains of *R. leguminosarum* isolated from the nodules of pea plants collected from diverse geographical locations in the State of Punjab.

Rhizobium strains were isolated from pea nodules produced by native rhizobia collected from different places. The standard procedure described by VINCENT (1970) was used for the isolation of the *Rhizobium* strains. Thirty strains were isolated based on morphological characteristics. One strain imported from Czechoslovakia and two strains obtained from I.A.R.I., New Delhi and P.A.U., Ludhiana, were also included in the present investigations.

The efficiency of all the 33 strains were tested on pea (*Pisum sativum* L.) var. Bounvilla using the Leonard jar technique. Eight strains were found to be highly efficient on the basis of dry weight of nodules and dry weight of the plant.

The method described by DATE—DECKER (1965) was used for the preparation of the antigens. Antisera against eight efficient strains were prepared and used in agglutination studies (VINCENT 1941).

A pot culture experiment was conducted to examine the competitive ability of efficient strains with native rhizobia. For this, seeds of pea (*Pisum sativum* L.) var. Bounvilla were inoculated with efficient strains individually and sown in earthen pots (25 cm in diameter) containing 8 kg unsterilized sandy loam soil. In a separate treatment all the strains were mixed in equal proportions and the seeds were inoculated with the mixed culture to determine the competitive ability of an individual strain in a mixed inoculation. 45 days after sowing, 40 nodules present on the root system were selected at random for the isolation of rhizobia, which were used as antigens for agglutination studies. The antigenic relationship of efficient strains with each other was also studied by the agglutination technique.

Out of the 33 strains of *R. leguminosarum*, 8 were found to be highly efficient on the basis of dry weight of nodules and dry weight of the plant in a Leonard jar experiment. The efficiency of the efficient strains was found to be in the order $PR_{27} > PR_{11} > PR_1 > PR_6 > > PR_{31} > PR_{10} > PR_{32} > PR_{33}$. Data on agglutination reveal that the different strains varied considerably in their ability to compete with native rhizobia to form nodules under pot culture conditions (Table 1). The ability of different strains to compete and dominate for nodulation ranged from 47.5 to 82.5%. Strain PR_{32} could not compete well with a naturally occurring population of rhizobia as it could form only 47.5% of the total number of nodules. By contrast, strain PR_{27} proved the best competitor because it produced the maximum number of nodules, i.e. 82.5% of the total number of nodules. The existence of strain variations in the competitive ability of *Rhizobium* strains has also been reported earlier (BROCKWELL—DUDMAN 1968, CHAHAL *et al.* 1978, DOROSINKII—MAKAROVA 1977). An inoculum consisting of multiple strains produced 96.4% nodules, but the contribution of the individual strains was quite different where each strain was applied as a monoculture inoculant. For

Table 1

Competitive study on efficient strains of R. leguminosarum to produce nodules on pea (Pisum sativum L.) var. Bounvilla

Source	Strain	Number of isolates tested	Number of isolates which gave agglutination	Nodules formed, %	Nodules formed in mixed culture, %
Gurdaspur	PR_1	40	22	55.0	3.3
Gurdaspur	PR_6	40	25	62.5	13.3
Ludhiana	PR_{10}	40	28	70.0	10.0
Ludhiana	PR_{11}	40	27	67.5	16.6
Hoshiarpur	PR_{27}	40	33	82.5	26.6
Czechoslovakia	PR_{31}	40	25	62.5	20.0
I.A.R.I., New Delhi	PR_{32}	40	19	47.5	0.0
P.A.U., Ludhiana	PR_{33}	40	21	52.5	6.6

instance, strain PR_{27} produced 82.5% nodules when used as a monoculture, but when used in a mixed culture it could only produce 26.6% nodules. Strain PR_{32} did not produce any nodules when used in a mixed culture. In a mixed culture the percentage nodulation by individual strains as revealed by the agglutination test was found to be in the order PR_{27} (26.6%) > PR_{31} (20%) > PR_{11} (16.6%) > PR_6 (13.3%) > PR_{10} (10%) > PR_{33} (6.6%) > > PR_1 (3.3%) > PR_{32} (0.1%). Strain PR_{27}, which was found to be the most efficient, also proved the best competitor in the mixed strain inoculum. In similar studies SKERDLETA (1973) and CALDWELL (1969) found D-216 and strain 110 respectively to be the best competitor in a mixed inoculum, as these strains produced the maximum number of nodules on soybean.

Based on the cross reactions of antigens with one or more antisera, and of differences in the agglutination titre values, 5 serogroups could be postulated for the 8 strains (Table 2). These serogroups were S-1 (PR_1), S-2 (PR_6, PR_{10} and PR_{11}), S-3 (PR_{11} and PR_{27}), S-4 (PR_{31}) and S-5 (PR_{33}). Some strains showed an antigenic relationship with other strains, whereas

Table 2

Serogrouping of efficient strains of R. leguminosarum based on somatic cross reactions

	Antisera							
	PR_1	PR_6	PR_{10}	PR_{11}	PR_{27}	PR_{31}	PR_{32}	PR_{33}
PR_1	5	-	-	-	-	-	-	1
PR_6	-	5	2	1	-	-	-	1
PR_{10}	-	2	5	3	-	-	-	1
PR_{11}	-	1	3	5	3	-	-	1
PR_{27}	-	-	-	3	5	-	-	1
PR_{31}	-	-	-	-	-	5	-	1
PR_{32}	-	-	-	-	-	-	5	4
PR_{33}	-	-	-	-	-	-	4	5

Numbers indicate highest dilutions of antisera showing agglutination
1 = 1/25 to 1/50, 2 = 1/100 to 1/200, 3 = 1/400 to 1/800, 4 = 1/1600 to 1/3200, 5 = 1/6400 or greater.

others did not. For instance, the antisera of strains PR_1 and PR_{31}, obtained from the Gurdaspur district and from Czechoslovakia, respectively, did not react with the antigens of any strains. On the other hand, strain PR_{31} cross-reacted with strains belonging to serogroups S-2 and S-3. This shows that some strains have an additional site to cross-react with other strains (JOHNSON—MEANS 1963). A homologous reaction of all the strains occurred at 1/6400 or greater dilutions. Two serogroups, S-1 and S-2, were present in the soils of the Gurdaspur district, whereas Ludhiana soils harboured serogroups S-2 and S-3. This occurrence of different serogroups in different soils may be dependent upon the type and composition of the soils (HAM *et al.* 1971, BEZDICEK 1972, CHAHAL *et al.* 1978). The soil composition varied considerably on the sites where the various strains were isolated.

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AMELIORATION OF SHRINKAGE CRACKS IN VERTISOL THROUGH AMENDMENT APPLICATION

Black clay soils (vertisols), which are found on almost every continent, constitute the largest area in India and form the most important soil group with respect to its agricultural potentialities (GOVINDARAJAN—GOPALARAO 1977). Because the composition of clay minerals in these soils is chiefly of the montmorillonitic type (ROY—DAS 1952) they show enormous swelling when wet and severe shrinking when dry, leading to deep cracking (SHARMA—VERMA 1977). However, very few attempts have been made to study the cracking aspect of these soils in relation to agricultural use. Although at present no adequate information is available from which to conclude unequivocally that shrinkage cracks are deleterious to the crop, increased evaporational losses through them are well documented (ADAMS—HANKS 1964, SELIM—KIRKHAM 1970, RITCHIE—ADAMS 1974). In addition shrinkage cracks have also been reported to cause damage to the plant roots (DAVIS 1965) and pose major physical constraint in the management of soils (SHARMA *et al.* 1978).

In view of the above, investigations were taken up on one of these black clay soils of Madhya Pradesh (Central India) to obtain preliminary information on the behaviour and amelioration of shrinkage cracks in relation to the type and method of amendment required under different vegetative covers.

A field experiment was conducted on a medium blackclay soil (Vertisol) of the Livestock Research Farm of J. N. Agricultural University, Jabalpur, India, by creating three different vegetative covers consisting of wheat (Variety Sonora 64), grass and cultivated fallow in a virgin grassland. Details of the soil, experimental set-up and techniques used have been described elsewhere (SHARMA—VERMA 1977). In brief, each of the three vegetative covers in plots 3×3 m in size, which were replicated three times leaving a headland of 0.5 m within and 1 m between the blocks, received eight treatments as follows:

T_1 no irrigation
T_2 irrigations
T_3 basal application of superphosphate at 200 kg P/ha + irrigations
T_4 cracks, when developed, filled with superphosphate + irrigations

T_5 basal application of rock phosphate at 200 kg P/ha + irrigations
T_6 cracks, when developed, filled with rockphosphate + irrigations
T_7 basal application of farmyard manure at 200 kg dry matter/ha + irrigations
T_8 cracks, when developed, filled with farmyard manure + irrigations.

These amendments (superphosphate, rockphosphate and farmyard manure) were applied by two different methods, basal application and crack filling. The basal application of amendments under all the vegetative covers was done prior to the wheat seeding by thorough mixing in the upper 10 cm soil (SHARMA—VERMA 1977). Crack filling was done 80 days after wheat seeding by pouring the required quantity of amendments into the cracks. In each plot a microplot 0.5 m square was marked out using four wooden pegs for making observations. Crack filling was limited to the microplots only. The volume of different amendments was equivalent to the crack volume in the microplot. To ensure that the amendment reached down to the bottom of the cracks, spatulas were used to push the material into the cracks. After the cracks were filled with the amendments, plots under all the treatments were irrigated on the same day with the help of a pump delivering water for a constant period so as to bring the soil well above saturation level.

The size of the cracks (width and depth) was recorded at 13–14 spots randomly chosen within the microplot of each plot and the average value was recorded as described earlier (SHARMA—VERMA 1977). The soil water content of the 0–7.5, 7.5–15.0, 15.0–22.5 and 22.5–30 cm soil layers was determined by the gravimetric method.

Before detailed results on the effect of amendment application on crack size are presented, it should be pointed out that at the time of irrigation, water from the adjoining plots seeped into the plots in treatment T_1 (no irrigation) through the large cracks developed in the plots as well as from the headland left within and between the blocks. This resulted in the swelling of the soil and thereby disturbed the crack size in these plots. Therefore, the data from T_1 are not presented here. Furthermore, the T_2 treatment, which was irrigated as the other remaining plots but received no amendments, has been considered as the "control" for the purpose of comparing the effect of various treatments on the crack size.

Crack width

The data on the width of the soil cracks as influenced by various treatments under different vegetative covers are presented in Tables 1 and 2, for 10 and 30 days after irrigation respectively. It is evident (Table 1) that at 10 days after the irrigation there was no difference

Table 1

Width of soil cracks (cm) as affected by amendment application for different vegetative covers at 10 days after irrigation*

Treatment	Vegetative cover		
	Wheat	Grass	Cultivated fallow
T_2	0.67	0.70	0.72
T_3	0.69	0.80	0.64
T_4	0.57	0.42	0.34
T_5	0.67	0.74	0.69
T_6	0.59	0.58	0.33
T_7	0.61	0.78	0.54
T_8	0.70	0.79	0.61
LSD (0.05)	N.S.	N.S.	0.15

* Mean of three replications. Value for each replication is based upon 13–14 observations.

Table 2

Width of soil cracks (cm) as affected by amendment application for different vegetative covers at 30 days after irrigation*

Treatments	Vegetative cover		
	Wheat	Grass	Cultivated fallow
T_2	0.99	0.86	0.75
T_3	1.16	0.91	0.81
T_4	0.61	0.44	0.38
T_5	1.05	0.78	0.76
T_6	0.65	0.55	0.37
T_7	0.98	0.92	0.61
T_8	1.02	0.91	0.71
LSD (0.05)	0.30	0.28	0.13

* Mean of three replications. Value for each replication is based upon 13–14 observations.

between the treatments in respect of the width of soil cracks developed for wheat and grass. But for cultivated fallow superphosphate and rockphosphate applied through the crack filling method (T_4 and T_6, respectively) reduced the width of the soil cracks significantly over the control (T_2). The effect of basal application of farmyard manure (T_7) was also significant.

At a later observation date (30 days after irrigation) the superphosphate and rockphosphate which had been applied through the crack filling method (T_4 and T_6, respectively) were found to be significantly effective in reducing the crack width over the control (T_2) for all the vegetative covers. The basal application of farmyard manure (T_7) was only found to be effective in reducing the crack width for cultivated fallow.

Table 3

Depth of soil cracks (cm) as affected by amendment application for different vegetative covers at 10 days after irrigation*

Treatments	Vegetative cover		
	Wheat	Grass	Cultivated fallow
T_2	3.79	5.44	4.12
T_3	4.80	6.75	3.56
T_4	4.29	3.64	2.75
T_5	4.14	5.40	4.28
T_6	4.54	4.66	1.90
T_7	3.81	5.89	3.44
T_8	4.61	5.16	3.48
LSD (0.05)	N.S.	N.S.	1.002

* Mean of three replications. Value for each replication is based upon 13–14 observations.

Crack depth

At 10 days after irrigation there was no difference between the treatments either for wheat or grass (Table 3). However, for cultivated fallow superphosphate and rockphosphate applied through the crack filling method (T_4 and T_6, respectively) reduced the depth of the cracks significantly over the control (T_2).

At a later observation date (30 days after irrigation) superphosphate and rockphosphate applied through the crack filling method (T_4 and T_6, respectively) were found to be significantly effective in reducing the depth of the cracks for all the vegetative covers (Table 4). However, the basal application of farmyard manure (T_7), which was effective in reducing the crack width under cultivated fallow, did not have any effect on the depth of the soil cracks.

Table 4

Depth of soil cracks (cm) as affected by amendment application under different vegetative covers at 30 days after irrigation*

Treatments	Vegetative cover		
	Wheat	Grass	Cultivated fallow
T_2	11.43	9.63	7.12
T_3	12.06	8.41	5.79
T_4	6.39	4.24	3.30
T_5	9.66	7.78	8.43
T_6	6.54	5.83	3.36
T_7	9.23	8.86	5.72
T_8	11.56	10.87	6.39
LSD (0.05)	3.42	2.25	2.81

* Mean of three replications. Value for each replication is based upon 13–14 observations.

Soil water content

The soil water content for all the vegetative covers was measured gravimetrically to a depth of 30 cm at 10 and 30 days after irrigation (Tables 5 and 6). At 10 days after irrigation the average soil water content in the upper 30 cm layer varied from 21.2 to 22.8% for wheat, 17.6 to 20.0% for grass and 19.8 to 21.9% for cultivated fallow. The water content at 30 days after irrigation in the same soil layer varied from 14.5 to 17.5%, 11.3 to 12.3% and 15.1 to 17.2% respectively for wheat, grass and cultivated fallow. However, there were no significant differences in the soil water content due to various treatments for any of the vegetative covers either at 10 or at 30 days after irrigation.

The results presented above show that as time advanced to 30 days from the irrigation (i.e. 30 days after the crack filling), superphosphate and rockphosphate applied through the crack filling method proved effective in reducing the size (width and depth) of the soil cracks for all the vegetative covers. At present no adequate information is available in the literature to suggest well-founded reasons for the effectiveness of these amendments in reducing the crack size. However, the effectiveness of superphosphate and rockphosphate in reducing the size of cracks could possibly be attributed to the presence of calcium in these amendments, which has a binding effect on the aggregates due to the formation of clay—Ca—organic matter complexes (STEVENSON—ARDAKANI 1972). At an early observation date (10 days after irrigation), however, the ineffectiveness of crack-filled superphosphate and rockphosphate in reducing the crack size for wheat and grass is attributed to the presence of roots. Immediately following irrigation, due to evaporation and water extraction by the roots, the amounts of water lost and consequently the extent of shrinkage in the upper surface layer for wheat and grass will be greater than that for cultivated fallow. Thus, the effect of the amendments in

Table 5

Soil moisture content (percentage on weight basis) up to 30 cm depth at 10 days after irrigation for various vegetative covers

Treatment	Depth (cm)	Vegetative cover		
		Wheat	Grass	Cultivated fallow
T_2	0 – 7.5	21.52	18.30	17.03
	7.5–15.0	23.18	19.41	21.30
	15.0–22.5	22.56	20.04	21.40
	22.5–30.0	23.64	20.31	21.75
	Average	22.72	19.51	20.37
T_3	0 – 7.5	19.19	14.81	18.93
	7.5–15.0	22.28	17.77	20.81
	15.0–22.5	21.86	18.90	21.79
	22.5–30.0	21.68	18.90	21.73
	Average	21.25	17.59	20.81
T_4	0 – 7.5	22.15	19.58	16.76
	7.5–15.0	23.14	19.99	21.19
	15.0–22.5	23.27	21.63	22.75
	22.5–30.0	22.99	20.12	22.75
	Average	22.89	20.33	20.86
T_5	0 – 7.5	21.07	17.04	15.44
	7.5–15.0	23.04	19.72	21.44
	15.0–22.5	23.89	18.06	21.22
	22.5–30.0	22.46	18.75	21.15
	Average	22.61	18.39	19.81
T_6	0 – 7.5	21.97	19.58	17.97
	7.5–15.0	22.48	20.14	20.71
	15.0–22.5	23.07	19.65	22.58
	22.5–30.0	23.60	20.54	22.79
	Average	22.78	19.98	21.01
T_7	0 – 7.5	22.11	19.52	20.13
	7.5–15.0	22.68	19.72	22.75
	15.0–22.5	21.88	19.63	22.39
	22.5–30.0	22.03	19.78	22.48
	Average	22.17	19.41	21.93
T_8	0 – 7.5	20.98	16.70	19.02
	7.5–15.0	21.62	17.45	21.67
	15.0–22.5	22.53	19.07	22.20
	22.5–30.0	22.26	20.80	21.82
	Average	22.84	18.50	21.17
Average over all the treatments		22.32	19.10	20.85
"F" test for treatments		N.S.	N.S.	N.S.

N.S. = Non significant

Table 6

Soil moisture content (percentage on weight basis) up to 30 cm depth at 30 days after irrigation under various vegetative covers

Treatment	Depth (cm)	Vegetative cover		
		Wheat	Grass	Cultivated fallow
T_2	0 – 7.5	4.11	9.10	6.49
	7.5–15.0	16.66	13.23	17.56
	15.0–22.5	18.81	13.12	18.18
	22.5–30.0	18.49	13.91	18.42
	Average	14.52	12.34	15.16
T_3	0 – 7.5	5.98	8.79	10.64
	7.5–15.0	18.14	12.70	17.50
	15.0–22.5	18.95	13.64	18.91
	22.5–30.0	18.68	12.12	18.60
	Average	15.43	11.81	16.41
T_4	0 – 7.5	7.57	7.12	5.35
	7.5–15.0	18.39	12.24	16.31
	15.5–22.5	17.53	12.54	19.56
	22.5–30.0	19.82	13.23	19.23
	Average	15.83	11.28	15.11
T_5	0 – 7.5	6.70	7.20	5.55
	7.5–15.0	17.76	11.33	17.25
	15.0–22.5	19.84	14.19	19.75
	22.5–30.0	18.86	13.75	18.83
	Average	15.79	11.62	15.34
T_6	0 – 7.5	7.79	8.82	11.69
	7.5–15.0	17.30	11.86	19.11
	15.0–22.5	19.10	13.35	18.23
	22.5–30.0	17.37	12.98	19.68
	Average	15.39	11.75	17.18
T_7	0 – 7.5	10.35	8.66	10.26
	7.5–15.0	17.16	12.85	18.01
	15.0–22.5	18.90	12.86	18.81
	22.5–30.0	19.06	14.51	18.36
	Average	16.36	12.22	16.36
T_8	0 – 7.5	10.80	7.91	6.24
	7.5–15.0	19.30	12.46	19.09
	15.0–22.5	20.96	12.56	19.58
	22.5–30.0	18.74	12.15	19.84
	Average	17.45	11.27	16.19
Average over all the treatments		15.82	11.75	15.96
"F" test for treatments		N.S.	N.S.	N.S.

N.S. = Non significant.

reducing the crack size is countered due to greater shrinkage. The effectiveness of the amendments would be further countered by the tendency of roots to contract the soil away from the cleavage planes towards the base of the plant (SHARMA—VERMA 1977).

It should be emphasized here that the idea behind stuffing the amendment (particularly superphosphate and rockphosphate) into the cracks at a later stage of crop growth followed by an irrigation was to bring the phosphate fertilizers, which are relatively immobile, into direct coordination with the root. This is expected to meet the plant's requirement for phosphorus, which is particularly high at the time of grain filling. Though the results of the preliminary study reported herein have shown that superphosphate and rockphosphate could be effective in ameliorating shrinkage cracks, it must be admitted that the feasibility of this method for field use on a large scale and the consequences of the treatment have yet to be considered.

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DIALLEL ANALYSIS OF RESISTANCE OF MAIZE TO EAR-ROTTING PATHOGENS

Maize is susceptible to ear-rotting fungi, which are distributed widely. These rots cause considerable damage in humid areas, especially when rainfall is above normal from silking to harvest. No inbred or hybrid is completely resistant under conditions favouring infection.

The inheritance of resistance appears to be controlled by several genes, i.e. it is polygenic. The most feasible way to control ear-rot is through breeding for resistance, as indicated by SMITH—MADSEN (1949), WISER *et al.* (1960), MANNINGER (1969), ULLSTRUP (1977) and HOOKER (1978).

Very little work has been reported on the genetics of resistance of maize to ear-rot disease. Therefore, this study was designed to obtain data that would add information on the inheritance of reaction to ear-rot and to evaluate a group of inbred lines from different sources and their hybrids for resistance to ear-rot.

The investigations were carried out at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, during the two seasons of 1978 and 1979. Seven inbred lines of maize, varying in susceptibility, were tested, namely four lines, D_3, D_4, D_5 and D_8, from the temperate zone with very different vegetation periods, one sub-tropical line, D_1, from Egypt, and two from synthetic populations of partly tropical origin D_6 and D_7, which had been inbred a number of times, S_4 and S_5, respectively. In 1977, these inbreds were crossed in all possible combinations to make a diallel cross, resulting in 21 hybrids, without reciprocal combinations. The experiment was designed as a randomized complete block with two replications. The parents and one set of 21 F_1 hybrids were assigned at random within each block. Entries were sown in two-row plots.

All the agricultural processes were carried out according to those usually used under the local conditions. Ten plants were artificially inoculated by a population of fungi (prepared from a suspension of milled infected grains) where the prevalent pathogen was F. graminearum, and were rated per plot. Inoculations were made after the majority of the silks had emerged. The ear was injected between the silks with about 2 ml spore suspension. Ratings were scored on individual plants during the harvest period in late October, based on the degree to which the ear was attacked by the pathogen, according to a scale from 1 to 9, where 1 = no apparent symptoms, 9 = whole ear visibly rotted, as given by MANNINGER (1977). Combined analyses of variance were performed on the means of 10 plants per plot in two seasons.

KEULS—GARRETSEN's (1977) procedure was used for combining ability.

The artificial inoculation assured that the plants were infected in different degrees. Disease scores were associated with inoculation with F. graminearum, which is considered the most common pathogen for ear-rot in the experimental area. Combined analyses of variance were computed with the combined data of the two years, because there was no significant difference between the two seasons, as shown in Table 1.

Table 1

Combined analysis for general and specific combining ability from diallel cross for ear rot ratings

Source of variation	d.f.	Mean squares	F. value
Entries	27	1.482	5.73**
GCA	6	0.993	3.84**
SCA	21	0.470	1.82*
Error	55	0.258	
CV%		11	

* Significant at 0.05% level
** Significant at 0.01% level

Analyses of variance showed that the differences between entries were real and highly significant for disease reactions. General combining ability (GCA) mean squares for ear-rot ratings were also highly significant. Specific combining ability (SCA) mean squares were significant. The ratio of GCA mean squares to SCA mean squares was about 2 : 1. Also, the F-values of GCA and SCA were equal to the F-value of the entries as presented in Table 1. This means that there are differences among 7 inbred lines due to GCA and/or to diverse sources. The coefficient of variation was reasonable (11%) according to the accuracy of the experiment.

The general combining ability mean square is a function of additive gene effects, dominance and epistasis, whereas the specific combining ability mean square is composed of dominance plus dominance types of interallelic interaction (GRIFFING 1956). However, mean squares for GCA were much greater than those for SCA, indicating a preponderance of additive gene effects in the inheritance of this disease for these seven inbred genotypes. Means of single crosses in the two seasons were used to calculate the general and specific combining ability

effects and are given in Table 2. Resistant inbreds D_7 and D_1 had the highest negative GCA effects of all inbreds. Inbreds D_8 and D_3 showed negative GCA effects similar to D_7 and D_1 but of much less magnitude. All other inbreds generally showed positive GCA effects. Inbreds D_5 and D_6 were less susceptible than the most susceptible inbred, D_4.

Although the specific combining ability effect (SCA) was significant, it was smaller than the GCA effect. However, single crosses having positive SCA effects in combined analysis over both seasons were $D_1 \times D_3$, $D_4 \times D_5$, $D_3 \times D_6$, $D_5 \times D_6$, $D_1 \times D_7$, $D_4 \times D_7$, $D_5 \times D_7$, $D_3 \times D_8$, $D_4 \times D_8$, $D_6 \times D_8$ and $D_7 \times D_8$. Resistant single crosses having negative SCA effects were $D_3 \times D_4$, $D_1 \times D_5$, $D_3 \times D_5$, $D_1 \times D_6$, $D_4 \times D_6$, $D_3 \times D_7$, $D_6 \times D_7$, $D_1 \times D_8$ and $D_5 \times D_8$.

Table 2

Mean ear-rot ratings of the single crosses (above diagonal) and the parent inbreds (diagonal). Estimates of general (GCA) and specific (SCA) combining ability effects are below the diagonal, combined for the two seasons

Inbred	D_1	D_3	D_4	D_5	D_6	D_7	D_8	Average of crosses for each parent
D_1	1.00^{e}	3.47	2.81	1.88	1.99	1.93	1.58	2.28
D_3	1.43	1.47^{de}	2.38	2.19	2.66	1.60	2.38	2.45
D_4	0.25	−0.39	3.37^{a}	3.36	2.32	2.73	2.79	2.73
D_5	−0.35	−0.26	0.39	2.43^{bc}	3.26	2.49	1.91	2.52
D_6	−0.24	0.22	−0.64	0.62	2.51^{b}	2.06	2.63	2.49
D_7	0.10	−0.45	0.17	0.25	−0.16	1.78^{cd}	2.05	2.14
D_8	−0.35	0.23	0.13	−0.43	0.30	0.12	2.02^{bcd}	2.22
GCA effects	−0.26$_{d}$	−0.05$_{c}$	0.47$_{a}$	0.15$_{b}$	0.13$_{b}$	−0.27$_{d}$	−0.17$_{scd}$	

Average of parent inbreds = 2.08. Average of all crosses = 2.36. $LSD_{0.05} = 0.70$. SE (GCA) = 0.13. SE (SCA) = 0.31

The F_1 hybrid between the most susceptible inbreds D_4 and D_5 was susceptible, while that between the resistant inbreds D_1 and D_8 was resistant. With respect to other crosses, it was apparent that little consistency was present. Therefore, these data suggest that SCA effects calculated from ear-rot ratings are of little value to the plant breeder in selecting inbred lines that carry resistance to ear-rot.

The data from this study indicate that additive gene action played an important part in the inheritance of resistance to ear-rot in this material and seemed to agree with those reported by WISER *et al.* (1960), BOLING—GROGAN (1965), NELSON—SCOTT (1973) and LIM (1975). Therefore, a breeding programme such as simple recurrent selection should be effective for developing new resistant inbred lines.

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STUDY OF RESISTANCE TO FUSARIUM GRAMINEARUM IN OPAQUE MAIZE LINES AND IN HYBRIDS PRODUCED FROM THEM BY DIALLEL CROSSING

"In the opinion of most maize breeders and producers the susceptibility of high lysine maize to Fusarium graminearum is a serious obstacle to its introduction into cultivation", as stated by M. I. Hadzhinov in a summarizing lecture delivered at the IXth meeting of Eucarpia (HADZHINOV—ZIMA 1977).

In the literature no unambiguous explanation of susceptibility to Fusarium graminearum is to be found. A knowledge of the cause would certainly help breeders of both normal and opaque maize to produce resistant hybrids.

GEORGIEV *et al.* (1977) carried out paired correlation calculations between protein content, lysine content, thickness of pericarp and hardness of kernel on the one hand, and reaction to Fusarium, Aspergillus, Gibberella and Penicillium fungi, on the other. On the basis of the paired correlation calculation there is no close relationship between these characters. The value of the multiple correlation coefficient is high, however, suggesting that these characters of the kernel in combination play a decisive role in the development of infection. When studying kernel rot caused by Fusarium moniliforme in normal and opaque inbred lines WARREN (1978) established a coefficient of correlation of $r = 0.62$ between the normal and opaque lines.

LOESCH *et al.* (1976), ORTEGA (1975), KOVÁCS—KOVÁCS (1979) and others report an increased susceptibility to ear Fusarium in opaque maize, noting at the same time that there are significant differences between the varieties.

In the present experiment the inheritance of resistance to Fusarium graminearum in opaque maize was studied in order to discover whether there were any hybrids which were resistant in farm practice and what the gene effects determining this property were.

The experimental material consisted of 9 inbred opaque lines and 36 F_1 hybrids produced from them in one-way diallel crosses. The inbred lines chosen on the basis of earlier observations included material which was resistant, moderately susceptible and susceptible to Fusarium graminearum.

The inbred lines and hybrids were included in a field trial at Szeged in 1975–1977. Besides evaluating the extent of natural infection, artificial inoculation was carried out with an isolate of F. graminearum by means of Yong's toothpick method. The isolate was prepared in the pathological laboratory of the Institute. The plants were then graded according to the extent of infection. The data were evaluated using GRIFFING's (1956) model and method.

The basic data are contained in Tables 1 and 2. The higher the value the more susceptible the respective material. An evaluation can be made on the basis of the order of the lines in the tables. The order from 1 to 6 is the same in the two tables; the only changes

Table 1

Data of infection to opaque lines and their F_1 hybrids under natural conditions

	1	2	3	4	5	6	7	8	9	Xi + Xii	Order
1. Oh43o_2	0.58	0.27	0.26	0.68	0.38	0.22	0.85	0.64	0.43	4.31	3
2. GKO 501		0.21	0.12	0.45	0.28	0.39	0.47	0.61	0.32	3.12	2
3. GKO 601			0.18	0.22	0.30	0.60	0.16	0.28	0.28	2.40	1
4. W64Ao_2				0.91	0.55	0.73	2.47	2.08	0.80	9.32	8
5. C123o_2					0.66	1.02	1.31	1.00	0.48	6.42	4
6. Szg25o_2						0.89	0.98	0.85	0.82	6.50	5
7. W153Ro_2							3.14	1.11	0.49	10.98	9
8. R181o_2								1.61	0.98	9.16	7
9. Mps156o_2									1.99	6.59	6

Average for parents: 1.13
Average for hybrids: 0.68

are found for lines showing the highest susceptibility, but the values here are very close to one another.

The hybrids and lines can be placed in resistant (R), medium susceptible (MS) and susceptible (S) groups on the basis of the limit values given in Table 3.

The limit values were established arbitrarily after nearly ten years of observation; they express what can be regarded in practice as a resistant hybrid. The intervals between the classes are not identical. The guiding principle was the fact that for the producer susceptibility or resistance to ear fusarium is a question of "yes or no". In order to illustrate the transition to some extent an intermediate category was included, though from the practical point of view hybrids included in this category must also be considered as susceptible. The difference between natural and artificial infection is one grade on the scale. Around the site of inoculation made with a toothpick several kernels become infected even in the case of resistant hybrids, giving a value one grade higher on scoring.

Table 2

Data of infection in opaque lines and their F_1 hybrids in response to artificial inoculation

	1	2	3	4	5	6	7	8	9	Xi + Xii	Order
1. Oh43o_2	2.58	1.55	1.26	1.97	1.81	1.75	2.09	2.10	2.05	17.16	3
2. GKO 501		1.82	1.09	1.69	1.55	1.56	1.85	2.25	1.25	14.61	2
3. GKO 601			0.68	1.43	1.32	1.42	1.12	1.44	1.16	10.92	1
4. W64Ao_2				3.05	2.75	2.05	3.28	3.90	2.90	23.02	9
5. C123o_2					2.06	2.25	1.96	2.24	2.05	17.99	4
6. Szg25o_2						2.78	2.26	2.45	2.31	18.83	5
7. W153Ro_2							3.97	2.13	1.86	20.52	7
8. R181o_2								2.94	2.22	21.67	8
9. Mps156o_2									3.84	19.64	6

Average for parents: 2.64
Average for hybrids: 1.95

Table 3

Limit values of resistance groups for inbred opaque lines and hybrids

	Resistant (R)	Medium susceptible (MS)	Susceptible (S)
Inbred lines			
Natural infection	0.01–0.50	0.51–1.50	1.51–5.00
Artificial inoculation	0.01–1.50	1.51–2.50	2.51–5.00
Hybrids (F_1)			
Natural infection	0.01–0.30	0.31–1.00	1.01–5.00
Artificial inoculation	0.01–1.30	1.31–2.00	2.01–3.00

Table 4

Resistance groups for parent lines and hybrids

Natural infection	1	2	3	4	5	6	7	8	9	Number of hybrids		
										R	MS	S
1. Oh43o$_2$	MS	R	R	MS	MS	R	S	S	S	3	2	3
2. GKO 501		R	R	MS	R	MS	MS	MS	MS	3	5	—
3. GKO 601			R	R	R	MS	R	R	R	7	1	—
4. W64Ao$_2$				MS	MS	MS	S	S	MS	1	5	2
5. C123o$_2$					MS	S	S	MS	MS	2	4	2
6. Szg25o$_2$						MS	MS	MS	MS	1	6	1
7. W153Ro$_2$							S	S	MS	1	3	4
8. R181o$_2$								S	MS	1	4	3
9. Mps156o$_2$									S	1	6	1

Artificial inoculation	1	2	3	4	5	6	7	8	9	Number of hybrids		
										R	MS	S
1. Oh43o$_2$	S	MS	R	MS	MS	MS	S	S	S	1	4	3
2. GKO 501		MS	R	MS	MS	MS	MS	S	R	2	5	1
3. GKO 601			R	MS	MS	MS	R	MS	R	4	4	—
4. W64Ao$_2$				S	S	S	S	S	S	—	3	5
5. C123o$_2$					MS	S	MS	S	S	—	4	4
6. Szg25o$_2$						S	S	S	S	—	3	5
7. W153Ro$_2$							S	S	MS	1	3	4
8. R181o$_2$								S	S	—	1	7
9. Mps156o$_2$									S	2	1	5

Table 5

Variances of general and specific combining ability

Designation	Degree of freedom	Average variance for	
		natural infection	artificial infection
General combining ability	8	1.27***	1.92***
Specific combining ability	36	0.21**	0.26**
Error	132	0.08	0.12
General/specific combining ability		6.05	7.38

*** Significant at 5% level
** Significant at 1% level

The resistance of the hybrids and their parent lines to F. graminearum is characterized (as R, MS, S) in Table 4. The statistical data on the right of the table show how the combinations of the respective lines are distributed among the categories. As a consequence of artificial inoculation the number of medium susceptible and susceptible hybrids increases, though the resistant category does not necessarily cease to exist. The method elaborated by GRIFFING (1956) for the evaluation of diallel experiments makes it possible to study the additive and dominant gene effects. Data obtained under natural and artificial conditions of infection were evaluated separately (Table 5). In both cases the general combining ability shows higher variance.

TURBIN *et al.* (1974) cite the authors Sprague, Tatum, Hayman, Matzinger and Kempthorne when stating that the general combining ability depends on the additive effects of the genes and on that part of the epistatic effect which originates from the interaction of genes with additive effects. The specific combining ability, on the other hand, depends on dominance and epistasis. Consequently it can be assumed that in the opaque hybrids examined the

Table 6

General combining ability of inbred opaque lines used in diallel crosses

Inbred lines	General combining ability for	
	natural infection	artificial inoculation
Oh43o_2	−0.25	−0.11
GKO 501	−0.39	−0.85
GKO 601	−0.46	−0.85
W64Ao_2	0.25	0.47
C123o_2	−0.05	−0.08
Szg25o_2	−0.03	0.07
W153Ro_2	0.59	0.33
R181o_2	0.28	0.34
Mps156o_2	0.08	0.24

resistance to F. graminearum is determined by additive gene effects. Since resistance to F. graminearum is transmitted by additive gene effects the method of selection can be successfully employed to improve this character. Using the evaluation method elaborated for diallel experiments the general combining ability was determined for each line (Table 6). The negative sign in the table indicates the transmission of resistance.

Among the inbred lines the highest number with a negative sign is found for GKO 601. This seems to be verified by the data in Tables 1 and 2, as GKO 601 was the line that transmitted resistance to the highest degree, i.e. the largest number of resistant hybrids were obtained with this line. Among the lines tested $W153Ro_2$, $W64Ao_2$ and $R181o_2$ also transmitted a considerable extent of resistance to F. graminearum. An analysis of the data in Tables 1, 2, 3 and 4 makes it clear that at least one of the parent lines must be resistant if an opaque hybrid resistant to F. graminearum is to be produced. The other parent may be resistant, medium susceptible or even susceptible, though naturally in the optimum case both parent lines are resistant. The practical proof of this statement is offered by the results of farm experiments on opaque hybrids. The hybrid GKO 601 × $W153Ro_2$ (resistant × susceptible) has been reproduced in an experimental quantity under the name SC 3365 HL. Between 1972 and 1980 the experimental production of this hybrid was carried out at 12 sites, on a total of 260 ha. In every case the harvested yield was free of Fusarium. From this it may be concluded that the higher susceptibility of opaque hybrids to ear Fusarium compared to normal hybrids is not a problem for the farmers. The development of resistant opaque hybrids can be realistically expected from maize breeders. Only opaque hybrids which are resistant to ear Fusarium can be recommended for commercial production.

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VARIATION TO LESS PATHOGENIC TYPES AS CAUSED BY A NEW DITHIOCARBAMATE FUNGICIDE IN ALTERNARIA BRASSICICOLA

Interference with some of the processes within the cell nucleus has long been recognized as a possible mechanism of fungicidal action.

A fungicide may interfere with nucleic acid synthesis, chromosome division; mitotic spindle formation, orientation, or function; induction of gene mutations or chromosomal aberrations; or increased recombination frequency. For example, if a compound caused nondisjunction of occasional chromosome pairs at some nuclei in the mitotic phase, it would

induce the formation of aneuploid nuclei, and eventually, easily recognizable haploid and non-disjunctional diploid sectors (somatic segregants) in colonies of a diploid fungal strain, heterozygous for the appropriate gene pairs.

Non-disjunction of chromosomes is not, of course, the only mechanism by which a diploid colony may produce sectors. Increased sectoring may be due to the influence of certain externally supplied chemicals. In the present investigation a new dithiocarbonate fungicide was tested for inducing sectoring in *Alternaria brassicicola*, a leaf spot pathogen of cruciferous plants.

During studies on the effectivity of certain new fungicides on certain necrotrophic parasites, variation was observed in one of the pathogens. A pathogenic strain of *Alternaria brassicicola* showed variation when grown on a culture medium containing 50, 100, 250 or 500 μg/ml of the fungicide. The fungitoxicity test on the fungicide was carried out by growing the fungus on Potato Dextrose Agar (PDA) supplemented with these four concentrations of the fungicide. A solution of the fungicide at the required concentration in acetone was added to the partially cooled medium before the plates were poured. The solvent concentration never exceeded 2% (v : v) in the agar medium and was found to be without effect on either growth or sectoring in control plates. Cork borer discs, 4 mm in diameter, obtained from 7-day old cultures of the fungus grown on PDA medium, were transferred to the centre of the plates and then incubated at 25 $\pm$ 1 °C. Six replicates were prepared for each treatment. Observation for growth inhibition and sector induction was recorded after 6–10 days of incubation.

A pathogenicity test for the new variants along with the original strain was carried out under controlled conditions (in vitro) and also in the greenhouse (in vivo). For the in vitro study, the Nurse Culture technique was used. Narrow strips of blotters were cut, having a width less than the diameter of the culture tubes. These were made into bridges of about 5 cm in length and placed in the culture tubes. About 10 ml of nutrient solution was added to each tube and autoclaved. Seeds were pre-treated with chlorine water and then shaken in 10-day-old culture tubes of the new segregants and the original culture. Pre-treated unloaded seeds were used as control. One seed was placed on the top of each bridge for germination. Fifty tubes were used for each treatment, and were incubated at 25 $\pm$ 1 °C under a 12-hour

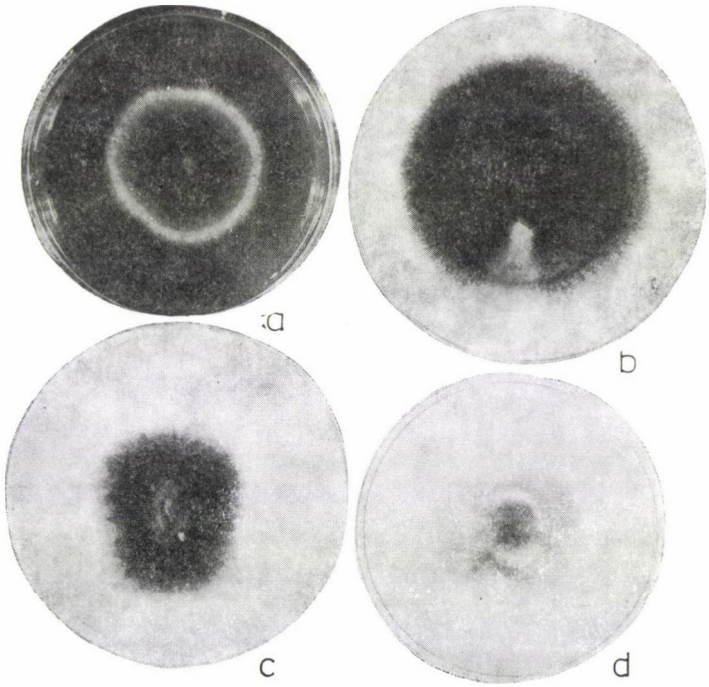

Fig. 1. Colonies of *Alternaria brassicicola: a)* non-treated (NT); *b)* treated (T) and showing segregation; *c)* and *d)* segregants "O" and "S" separately

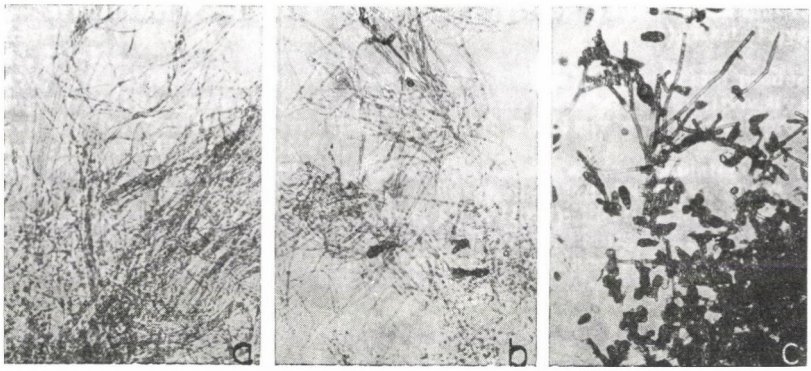

Fig. 2. Sporulation: *a)* from "S" variant with no conidia; *b)* from "O" variant with few conidia; *c)* from non-treated coloby "NT" with numerous normal conidia

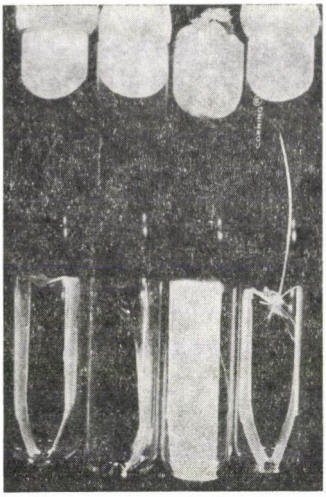

Fig. 3. Pathogenicity test: *a)* in vitro test, *b)* in vivo test; here plants treated with variant "S" show slightly better growth but their number has decreased compared to control "C"

alternating cycle of fluorescent light and darkness; they were examined after 15 days for germination and symptoms.

For the greenhouse trial, 3 inch pots were used. The soil in the pots was autoclaved at 1.41 kp/cm^2 for 1.5 hr, and left for one week before infection. The two new strains and the original strain of the pathogen were cultured on liquid PDA medium in 100 ml conical flasks and incubated at 25 $\pm$ 1 °C for 10 days. After this period the fungus from each flask was taken out and shaken with about 25 ml sterile water and added to 2 pots in equal quantities. The inoculum was then allowed to develop in pots for a week. 30 pre-sterilized seeds of Snowball Group Variety of cauliflower were sown in each pot. Pots sown without inoculum served as control. Observations of germination were recorded after 10 and 15 days, respectively.

The effect of bis N-(ethyl, m-tolyl)-dithiocarbamato Cu(II) on the growth rate of *Alternaria brassicicola* in vitro was different under the influence of concentrations 50, 100, 250 and 500 μg/ml. The growth rates (expressed as a percentage of the control, grown on non-amended medium) were 84.6, 78.0, 74.6 and 60.2% resptectively after 6 days. The effect of the fungicide on the colony characters of the fungus was also observed. All four concentrations of the fungicide caused the variation of new types from the original. In all these treatments, two new types of variants appeared. The original culture (non-fungicide treated) was labelled "NT" and it exhibited the characteristic features as given by ELLIS (1971). The two new variants were labelled "O" and "S". When the new variants "O" and "S" were transferred to fungicide-free medium, the characters were retained permanently. The main differences in the characteristics of the three types is given in Table 1 and Figs 1 and 2.

In the case of the pathogenicity test, it is evident from Table 2a, b and Fig. 3a, b that the two variants (O, S) were less pathogenic than the original type (NT), both in the field experiments and in the Nurse Culture Technique.

From the results of the present work it is clear that although the fungicide does not completely inhibit fungal growth (the inhibition was only 60% using 500 μg/ml), it proved that it has a good ability to induce somatic variants which are different in their cultural characters as well as in their pathogenicity. The variation in the pathogen may be because the site of action is located within the nucleus (GEORGOPOULOS *et al.* 1976).

It is well known that most fungicides normally prevent the growth of the pathogen or at least inhibit it to a large extent. The present fungicide may be useful since it induces the formation of less pathogenic variants. This aspect may lead to a good new look at the chemical control of destructive pathogens.

Table 1

Differences in the characteristic features of the three types of Alternaria brassicicola grown at 25 $\pm$ 1 °C for 6 days

Characteristic	"S"	"NT"	"O"
Colour	greenish-grey	greenish-black	dark blackish-brown
Texture	rough, with more aerial hyphae	slightly rough with less aerial hyphae	smooth, flat, velvety
Sporulation	very little to none; conidia 1–2 celled, abnormal, up to 364.0 spores/mm^2	comparatively little, conidia 1–3 celled, never more than 3 in a chain; olivaceous in mass, smooth, about 2436.0 spores/mm^2	normal; conidia normal, up to 20 or more in chains, 1–7 celled, smooth to slightly warted; about 3545.7 spores/mm^2

Benomyl (HASTIE 1970, KAPPAS *et al.* 1974) and Griseofulvin (KAPPAS—GEORGOPOULOS 1974) were earlier reported to induce sectoring in diploid colonies of *Aspergillus nidulans.* Mitomycin C and S-fluorodeoxyuridine have also been shown to induce mitotic crossing-over in other fungi (ESPOSITO—HOLLIDAY 1964, HOLLIDAY 1964). Some of the aromatic hydrocarbon group have also been reported to interfere with the nuclear function in fungi (GEORGOPOULOS—ZARACOVITIS 1967, GEORGOPOULOS *et al.* 1976) as well as in higher organisms (WUU—GRANT 1966).

Table 2a

Pathogenicity test on the three types of A. brassicicola in the Nurse Culture Technique

	Parameters			
	"NT"	"O"	"S"	Control (pots without inoculum)
Germination (%)	22	34	90	99
Mean of length (mm)				
Root	3.5	4.9	7.8	8.5
Shoot	2.5	4.1	7.5	8.0

Table 2b

Pathogenicity test on the three types of A. brassicicola grown in the field

Percentage disease after	Parameters			
	"NT"	"O"	"S"	Control (pots without inoculum)
10 days	20.90	18.53	17.07	00.0
15 days	36.02	33.55	20.29	00.0

Although the results obtained in this work are mainly discussed from the point of view of fungitoxic mechanisms, it should be stated here that the use of fungicides which affect hereditary processes may have an impact on other organisms, including man.

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LECTIONES

INHERITANCE OF LYSINE CONTENT BY CROSSING WITH OPAQUE-2 MUTANT*

The transmission of the O_2 gene in inbred lines and hybrids is an important part of breeding maize for chemical composition. The lysine content of the mutant considerably exceeds that of maize with a normal endosperm. The transmission of the character can be studied well in "normal × mutant" crossings. The results can be utilized in producing hybrids with better components.

The higher lysine content of maize endosperm mutants and the difference in their amino acid compositions compared to normal maize have been demonstrated by a number of authors (MERTZ *et al.* 1964, LAMBERT—ALEXANDER 1968, GUPTA *et al.* 1975). Irradiation has also been used to produce such mutants (MENYHÉRT 1971, BÁLINT 1977). The present authors have also published several accounts of the favourable composition and agronomical characteristics of the Opaque-2 breeding stock (KOVÁCS 1979, KOVÁCS—KOVÁCS 1979). Mutants have been dealt with by many foreign authors as well (ALEXANDER *et al.* 1969, HADZHINOV *et al.* 1972, GENEVOIS 1973, GUPTA 1975, GURYEV—TIMCHUK 1979). The recessive inheritance of the O_2 gene has similarly been reported. Some authors have attempted to introduce the O_2 gene in known inbred lines (ALEXANDER *et al.* 1969, BÁLINT 1977, HADZHINOV *et al.* 1972) but relatively few experiments have been carried out on the transmission of the O_2 gene to an inbred line and its transfer to a particular hybrid (e.g. a complex method involving crossing, backcrossing and inbreeding). The experience gained in this field in Hungary, with known lines of Hungarian hybrids, are of particular interest to the authors.

The present experiments were aimed at studying the lysine content in O_2 × line combinations and in hybrids produced with such lines, to find out what influence the O_2 gene exercises on the lysine content of the parents and how the lysine content of the parents manifests itself in the SC, TC and DC hybrid combinations. A more distant aim was to examine the possibility of producing variations of original hybrids carrying the O_2 gene.

The experiments were carried out under field conditions, as were the artificial crossings. The lysine content was determined with an automatic amino acid analyser (LKB-4101). The experimental plant material included Opaque-2 (M-Opaque) and Floury-2 mutants, known inbred lines, inbred lines produced by the authors, and standard maize hybrids with normal endosperms which could be cultivated in the area in question (North-West Hungary).

Lysine contents of mutants and inbred lines: To begin with, our own endosperm-mutant stock, and the lysine contents of inbred lines and standard hybrids were examined. The results of the analyses are shown in Table 1.

In different crop years the lysine content of the O_2-mutant was 3.16–4.51% (protein %), with an average of 3.91%. The corresponding value for the Fl_2-mutant was 3.70%. The lysine contents of all maize hybrids with normal endosperms were lower than those of the mutants.

The inbred lines contained less lysine than the mutants; their lysine content was generally closer to that in the standard hybrids, and occasionally even exceeded it.

The inbred lines studied and their lysine contents are as follows: 156 sz. (2.36%), 118/b (2.95%), N-6 (1.96%), W 153 R (2.62%), Ia 153 a (2.23%), B-14 (2.72%), J-59 (2.58%) and VIR-44 (1.92%). Further lines examined were BDC-3141, I-54-4162, C-22, WF-9, C-5, K-3563, T-5 and O-14, some of which were used in subsequent crosses.

The lysine contents of the lines examined deviated considerably, ranging from 1.91 to 2.95%, with an average of 2.51%.

* Paper presented at the XIth ESNA Congress, Debrecen, 24–30th August 1980.

Table 1

Lysine contents in mutants and inbred maize lines with normal endosperms
(Mosonmagyaróvár, 1975–1979)

Variant	Lysine (% of protein)	Type
O_2	3.91	mutants
Fl_2	3.70	mutants
156	2.36	
118/b	2.95	
N-6	1.96	
W 153 R	2.62	lines
Ia 153	2.23	
B-14	2.72	
J-59	2.58	
GJ	1.96	variety
VIR-44	1.92	line
BDC-3141	2.50	
I-54-4162	2.50	
C-22	1.96	
WF-9	2.14	
C-5	2.62	lines
K-3563	2.33	
T-5	2.69	
O-14	1.91	
st. Mv SC-380	2.41	
Sz SC-363	2.86	hybrids
Sze SC-369	2.01	
KSC-360	2.47	

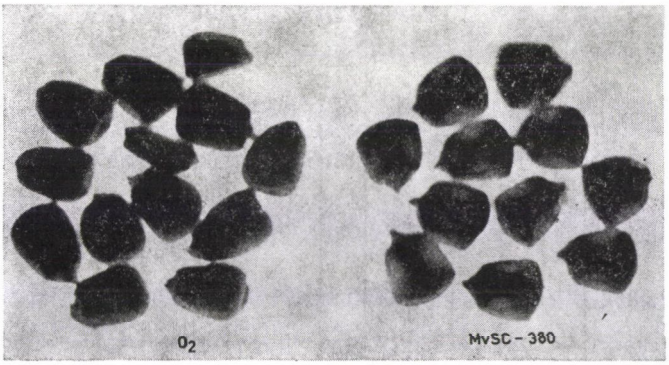
The standard hybrids grown in the area contained 2.43% lysine on average. Mv SC-380 contained 2.41%, SzSC-363 2.86%, KSC-360 2.47% and SzeSC-369 (the most recent standard hybrid, available since 1979) 2.01% lysine.

Lysine contents in inbred line $\times O_2$-mutant crosses: Inbred lines were crossed with the O_2-mutant. After one or two back-crosses (BC_1, BC_2), followed by selfing and inbreeding (S), the presence of the O_2-gene was examined in each ear by illuminating the endosperm (Fig. 1). The amino acid composition and the lysine content were then analysed.

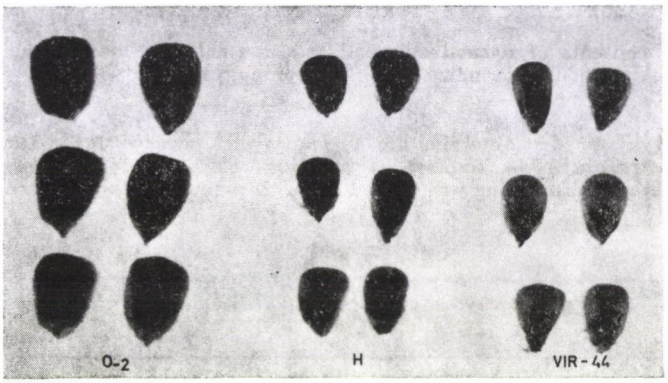
The results of crossing lines with mutants are presented in Table 2.

The lysine contents of the combinations for certain well-known lines were: 156 $(2.36) \times O_2 = 2.37\%$, 118/b $(2.95) \times O_2 = 2.72\%$, N-6 $(1.96) \times O_2 = 2.24\%$, W 153 R $(2.62) \times \times O_2 = 3.47\%$, Ia 153 $(2.23) \times O_2 = 3.45\%$, B-14 $(2.72) \times O_2 = 2.75\%$, J-59 $(2.58) \times O_2 = = 2.76\%$, VIR-44 $(1.92) \times O_2 = 2.12\%$ and G J $(1.96) \times O_2 = 3.66\%$.

The general tendency for most combinations was for the lysine content to fall between the original value of the line and that of the O_2 (3.91%). The average was 2.37% for the lines and 2.84% for the crosses, i.e. the lysine content increased under the influence of the O_2-gene, but to an extent that varied from line to line.



a)



b)

Fig. 1. O_2-mutant and maize with a normal endosperm *(a)* and their cross *(b)* illuminated

Table 2

Percentage of lysine contents in inbred maize lines × O_2 combinations
(Mosonmagyaróvár, 1978)

Hybrid combination	♀	H	♂	Production route
156sz × O_{-2}	2.36	2.37	3.91	BC_2
118/b × O_2	2.95	2.72	3.91	BC_2
N-6 × O_2	1.96	2.24	3.91	BC_1
W153R × O_2	2.62	3.47	3.91	BC_1
Ia 153 × O_2	2.23	3.45	3.91	BC_1
B-14 × O_{-2}	2.72	2.75	3.91	BC_2 + S
J59 × O_2	2.58	2.76	3.91	BC_2 + S
VIR44 × O_2	1.92	2.12	3.91	BC_2 + S
GJ × O_2	1.96	3.66	3.91	BC_1 + S

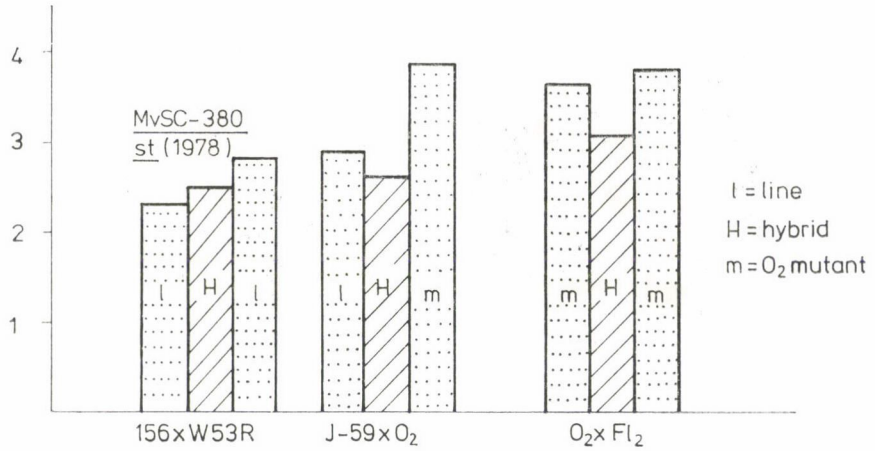


Fig. 2. Lysine contents of normal × normal (st.), normal × mutant and mutant × mutant endosperm maize crosses (Mosonmagyaróvár, 1978)

Crossing was aimed at obtaining line-analogues with higher lysine contents. The result depended on the number of backcrosses, as well as on which parent was represented by the mutant and whether backcrossing was carried out with a mutant or with a line.

Table 3

Percentage lysine contents in SC, TC and DC hybrids
(Mosonmagyaróvár, 1978)

	♀	H	♂
SC hybrids			
1. $O_2 \times$ J-59	3.91	2.96	2.58
2. K-3563 $\times O_2$	2.33	2.37	3.91
3. $Fl_2 \times O_2$	3.70	3.29	3.91
4. BDC-3141 $\times O_2$	2.50	2.68	3.91
5. J-59 × C-5	2.58	2.63	2.62
TC hybrid	SC ♀	*H*	♂
6. (J59 $\times O_2$) × K-3563	2.76	2.64	2.33
DC hybrids	SC ♀	*H*	SC ♂
7. ($O_{-2} \times$ J-59) × (K3563 $\times O_2$)	2.96	2.92	2.37
8. (K3563 $\times O_2$) × ($O_2 \times$ J59)	2.37	2.91	2.96
9. ($Fl_2 \times O_2$) × (K3563 $\times O_2$)	3.29	2.71	2.37
10. (J59 × K3563) × (BDC-3141 $\times O_2$)	2.32	2.32	2.68
11. (J-59 × C-5) × (BDC-3141 $\times O_2$)	2.63	2.50	2.68
st. MvSC-380		2.41	

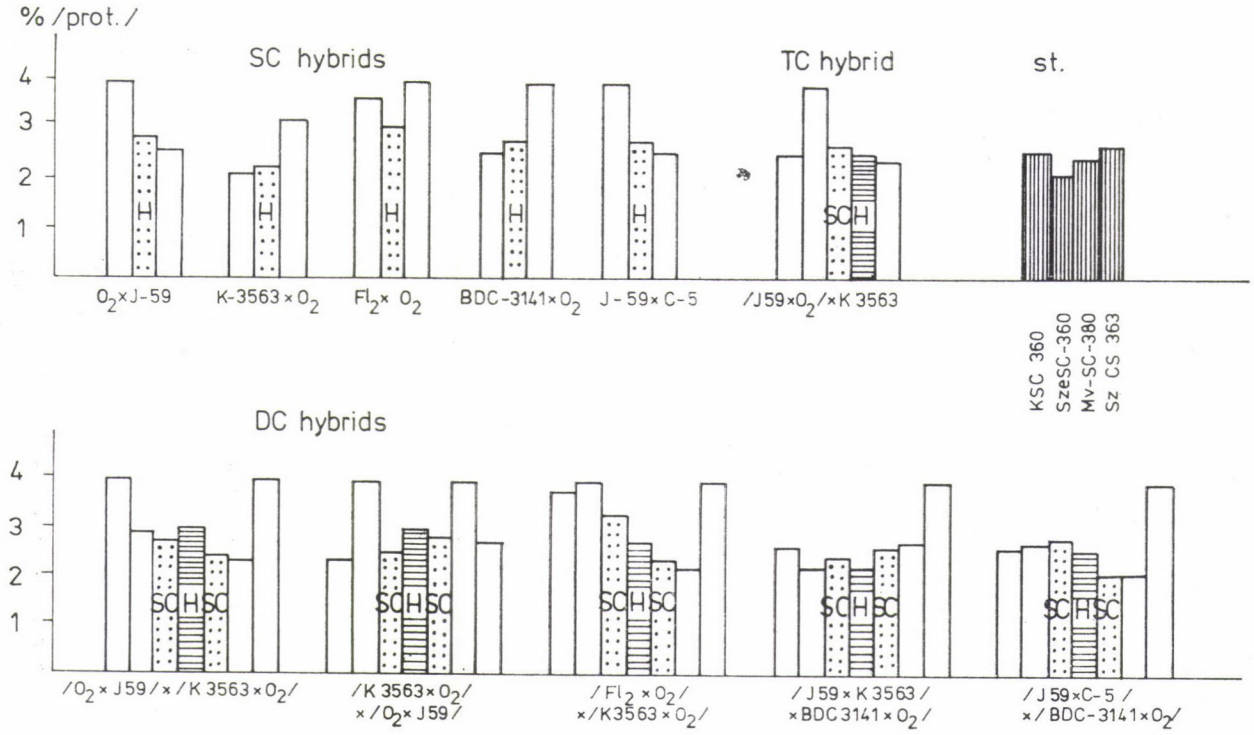


Fig. 3. **Lysine contents in SC, TC and DC hybrids produced with the O_2 mutant, and in standard maize hybrids (Mosonmagyaróvár, 1978)**

Normal × normal, normal × mutant and mutant × mutant combinations were compared for lysine content. For the mutant × mutant combinations the Fl_2 (3.7%) mutant was used. The results are shown in Fig. 2.

The lysine content is lower when both parents have normal endosperms, and has a value intermediate to those of the two parents; it is higher when one of the parents is a mutant and the highest when both parents are mutants. In the two latter cases the tendency is the same; the lysine content is lower than those of the parents, indicative of the recessive inheritance of the character, but is higher than in the normal hybrid.

The lysine content can be increased by inbreeding, since the recessive gene effect is better manifested. A dominant O_2 gene could thus open up new perspectives in breeding for chemical composition.

Evaluation of lysine contents in SC, TC and DC hybrids: SC, TC and DC hybrid combinations produced with lines in the manner described above were subsequently compared for lysine content. The results can be seen in Table 3 and Fig. 3.

It can be seen that the lysine content of the SC hybrids (2.79%) is closer to that of the parent with the lower value. The TC and DC hybrids have lower average lysine contents (2.67%). However, the lysine content in the DC hybrids produced by the authors is still slightly higher than that of the standard hybrid with normal endosperm (2.41%). The lysine contents of the SC, TC and DC hybrid combinations and standard hybrids, as well as the quantity of lysine in the hybrids compared to the parents are well illustrated in Fig. 3. A comparison between the lysine contents of SC and DC hybrids leads to the conclusion that in multiline hybrids the original lysine content of the mutant is manifested to a lesser extent than in the SC hybrids.

Lysine content of hybrids produced with a parent carrying the O_2 gene: It also seemed warranted to make a comparison between the original line and its hybrid, and between the line carrying the O_2-gene and its hybrid with respect to lysine content. This was carried out with Mv SC-380 and the combination G J × VIR-44. The results are shown in Table 4.

In the case of the first hybrid the lysine content of the original parents (156, W 153 R) was lower than that in the analogue containing the O_2-gene. The lysine content of the original hybrid was 2.62%, while that in the hybrid produced with lines containing the O_2-gene was 2.90%.

Table 4

Modification of Lysine content in hybrids with normal endosperms due to the presence of the O_2-gene

Hybrid	Combination	Lysine, %
1. Mv SC-380	156 sz	2.36
normal hybrid	156 × W153 R	2.41
	W153 R	2.62
variation carrying O_2-gene (analogue)	156 O_{-2}	2.37
	156 O_2W153 R-O_2	2.90
	W153 R O_2	3.47
2. GJ × VIR 44		
normal hybrid	GJ	1.96
	GJ × VIR-44	1.94
	VIR-44	1.92
variation carrying O_2-gene (analogue)	GJ. O_2 (BC_2)	3.66
	GJ. O_2 × VIR-44	2.12
	VIR-44	1.92
3. $O_2 \times Fl_2$		
mutant × mutant (reciprocal)	O_2	3.91
	$O_2 \times Fl_2$	3.03
	$Fl_2 \times O_2$ (reciprocal)	3.29
	Fl_2	3.70

For the second hybrid, one of the parents (GJ) contained the O_2 gene and had a much higher lysine content than the original hybrid. When used as a crossing partner, as the maternal parent, the lysine content of the hybrid combination carrying the O_2 gene was higher (2.12%). The original hybrid contained 1.94% lysine. The highest lysine content was obtained with the $O_2 \times Fl_2$ combination. In these hybrids the lysine content was higher (3.03%, reciprocal 3.29%) than any of those found in the previous combinations. None of the other hybrid combinations showed a lysine content above 3.0% (Fig. 3).

Summing up the results the following dacts can be established: 1. The transmission of the O_2-gene in inbred lines increased the lysine content, though the latter was closer to the value found for the parent with the lower lysine percentage. 2. The effect of the O_2 gene depended on which of the parents was represented by the mutant, and whether backcrossing was carried out with the normal or the mutant parent. 3. The lysine content was higher in the SC hybrid combinations (2.79%) than in the TC and DC hybrids (2.67%), though the lysine contents of these hybrids were still higher than that of the standard hybrid with a normal endosperm (2.41%). 4. The lysine contents of analogous hybrids produced with lines containing the O_2-gene increased from 2.41 to 2.90% in the case of Mv SC-380, and from 1.94 to 2.12% for the combination GJ $O_2 \times$VIR-44. The highest lysine contents were obtained for the $O_2 \times Fl_2$ (3.03%) and $Fl_2 \times O_2$ (3.29%) combinations.

It would also be worth evaluating the higher lysine content in connection with other amino acids and with the agronomical characters.

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CHRONICA

LÁSZLÓ BERZSENYI-JANOSITS
(1903–1982)

László Berzsenyi-Janosits, a Hungarian plant breeder of European fame, one of the most outstanding researchers in his field over the last half century, was born in Fiume on 2nd September 1903. He was that rare brand of scientist who cleverly, and above all successfully, combined his wide theoretical knowledge with practical work.

As usual in those days he began as a temporary assistant and felt it a favour to be able to continue his studies unaided. As a talented and educated young man he wished to become a creative agriculturist through experimentation, teaching and research.

The instruction and example given by Cserháti and Gyárfás had a considerable influence on the way he broadened and deepened his professional knowledge. However, the greatest effect on his career was perhaps exercised by Emil Grábner, who was at the head of the Hungarian Institute for Plant Breeding from 1910 onwards. László Berzsenyi-Janosits obtained a post at the Institute in 1928. Plant breeding in Hungary was in its vigorous young days at that time. At the Kompolt Plant Breeding Station established on the initiative of Elemér Székács, the first results of the pioneer work carried out by Rudolf Fleischmann, now regarded as a master of his profession, were already coming to fruition. Besides Óvár and Kompolt the breeding establishments at Bánkút, Mindszentpuszta and Lovászpatona also achieved results that made their effects felt in plant growing all over the country.

The "Magyarization" of the ancient German school yielded fine results. The experimental testing of the new varieties was an entirely new task, from which László Berzsenyi-Janosits, who was already known as an expert, could not be left out. An important role in this work was played by the Experimental Station for Plant Production at Óvár, which was directed by Professor János Surányi. In this institute László Berzsenyi-Janosits made good

use of his knowledge and experience from 1935 to 1937. At about that time, in advance of many developed European countries, a network of plant production and variety trials evolved, which, after being reorganized several times, later formed the basis of the present system of variety testing.

In the meantime a new director, Ödön Villax, took over the supervision of theoretical and practical plant breeding in Hungary, which had already reached a high standard. He could not have found a better deputy than László Berzsenyi-Janosits, who spoke the most important western languages fluently, and successfully influenced professional views and, through his numerous scientific publications, the course of experimental and research work. Thus, László Berzsenyi-Janosits, who was now familiar with the methodology of variety trials and plant production experiments, again occupied an important post in the direction of research.

During World War II he was sent as a state official to Kolozsvár and Marosvásárhely, where he achieved brilliant initial successes in the organization of education, extension training and experimentation. The end of the war found him at Óvár again, where the relaunching of the disrupted plant breeding was one of his major duties. He played an important role in saving, re-evaluating and distributing the invaluable breeding stock to plant breeders working in other research establishments throughout the country. His work in organizing regular extension training for Hungarian plant breeders and in establishing a team of highly educated special technicians was also of a pioneer character. This work had been begun in Emil Grábner's active years, and László Berzsenyi-Janosits was one of the most efficient instructors and organizers in this field, too.

However, it was in his work as a maize breeder that his creative talent found its true fulfilment. Together with Rudolf Fleischmann and Endre Pap he was among the first to recognize the vast possibilities hidden in Hungary's most important agricultural plant. By the second half of the forties László Berzsenyi-Janosits had an expert knowledge of heterosis in maize, which he later applied very successfully. As a leading plant breeder he had the opportunity to establish relations with foreign institutions and to obtain the most up-to-date inbred maize lines from the United States of America. Having tested them under Hungarian conditions he then passed them on to other Hungarian maize breeders. It was largely to his credit that the first Hungarian inbred maize hybrid was produced by the beginning of the fifties, thus preceding the most important maize-producing countries of Europe.

As a consequence of the rational division of the work of maize breeding, Magyaróvár was charged with the production of varietal hybrids, in which Berzsenyi-Janosits achieved perhaps the greatest success of his life. Among the four varietial hybrids produced, Óvári 5 was the most important, being very profitably grown on an area of 200 000 cad. yoke (approx. 140 000 ha) as early as 1959.

As an indirect, though almost equally valuable result of his work, he called attention to the hybridization possibilities inherent in the Hungarian improved maize varieties. In particular, lines originating from the varieties Mindszentpusztai white flint and Fleischmann's Mezőhegyesi dent corn became the permanent building materials for his creative work. Simultaneously with his production of varietal hybrids, it became obvious that the Hungarian breeding material by itself was no longer sufficient to achieve greater and more permanent results (as proved by the hybrid Mv 5, produced by Endre Pap at Martonvásár). The modern conception at the time was represented by the crossing of lines originating from the U.S.A. with selfed lines selected from Hungarian improved varieties. This was the characteristic feature of breeding practice up to the second half of the seventies.

László Berzsenyi-Janosits carried out very useful work in the first half of the fifties as the head of the maize breeding team. The publication of the "Guide", which ran to five editions, and the book "Hybrid maize" in 1958, brought him undying distinction. This book, written in fine Hungarian and containing the most up-to-date international knowledge then available, made the theory and practice of maize breeding and seed production public knowledge. This competent teaching and propaganda work was partly responsible for the fact that by 1964, sooner than in any other country in the world, practically the total maize area of Hungary was sown to inbred hybrids. Berzsenyi-Janosits' booklet was a "must" for all those involved in organizing seed production or in managing seed producing farms. This book was not only of great use a quarter of a century ago, but served as a valuable guide for young specialists in the sixties and seventies, and is still an excellent source-book for everyone working in this field.

The repeated reorganization of agricultural research also modified the life and career of Berzsenyi-Janosits. In 1959 he found himself at the head of the Plant Production Department of the Keszthely University of Agricultural Sciences. From breeding varietal hybrids he had to change over to producing hybrids with a short vegetation period. He set to work with great enthusiasm, and less than ten years later the first Georgikon hybrid was state

registered (Georgikon 250 in 1967). This saw the start of a new period when early and very early hybrids were grown in Hungary, and breeding at Keszthely was given a fresh impulse.

In the meantime, still as a result of his work at Magyaróvár, a late silage maize hybrid registered as Keszthelyi 22 (1962) was produced; as regards yield potential only the most successful hybrids of the present decade can compete with it. The hybrid Keszthelyi 22 confirmed the generally correct view that hybrids produced by crossing varieties (mainly flint) native or bred in Europe, or the inbred lines obtained from them, with inbred (mainly dent) lines from the U.S.A. are the most successful biological starting points for European maize production. (Simultaneously with Keszthely 22, the Hungarian hybrids Mv 1, Mv DC 602, Mv 59 and Mv SC 530, and the French hybrid Lg 11, the European "star" in the seventies, proved the correctness of this statement. It is also worth mentioning that one of the most promising short vegetation hybrids of the eighties, "PIONEER hybrid 3839", is the most recent proof of this.)

The modernization of hybrid maize breeding in Hungary, and the widening of its capacity, made it possible to start a joint breeding programme with foreign breeders, particularly with those in the German Democratic Republic. László Berzsenyi-Janosits became the first Hungarian co-ordinator of this joint programme. He wisely co-ordinated and directed the activities of breeders working with early breeding stock at Martonvásár, Szeged and Keszthely, always keeping the common interests in view, never local ones. The results of joint experimentation led to the first two Georgikon hybrids (Georgikon DC 250 and Georgikon TC 302) temporarily becoming important in the silage maize production of the GDR, marking the start of the most successful international breeding programme in Europe. This work rightly deserves the epithet "highly successful", as the first common hybrid, BEKE 270, was produced within seven years of the beginning of co-operation; in the GDR it was state registered in 1972, and in Hungary in 1973 (BEKE = BERNBURG—KESZTHELY). Not only the work, but the use of the results was common too; BEKE 270—and later BEMA 250—revolutionized the production of early silage maize in Hungary, in the true sense of the word. If the basic principles of this maize breeding work, represented by Berzsenyi-Janosits among others, are examined, it is found that the classic principle is repeatedly confirmed: a line obtained from a variety native in the GDR (F/5 Fix) crossed with Canadian (C44) and Minnesotan (A 90) lines selected and maintained in Hungary gave rise to BEKE 270, the epoch-marking hybrid jointly bred by researchers at Keszthely and Bernburg.

It was also due to Berzsenyi-Janosits' work in the field of international co-operation that when the Polish breeders joined the Hungarian–GDR co-operation in 1973 they did so as former pupils. Hybrid maize breeding in Poland started in 1955–56 mainly under the guidance of Hungarian consultants. Polish breeders still think of László Berzsenyi-Janosits and Endre Pap as their masters. They also worked together on the concepts which later justified and determined the introduction of silage maize breeding in Poland.

László Berzsenyi-Janosits gained great distinction by initiating scientific relations with the countries of Western Europe, primarily, of course, within the framework of EUCARPIA. At the 1965 EUCARPIA congress in Vienna the necessity of breeding short vegetation maize hybrids and the methods which he too used were fully confirmed. He returned home rich in experiences and eager to act. From then on the breeding of early hybrids was continued at a still greater pace.

Besides Keszthely 22 he was co-breeder of five other state registered hybrids, of which Keszthelyi SC 360 was of outstanding importance. Together with Szarvasi SC 363 and Mv SC 580 this meant that up-to-date Hungarian SC hybrids had come into existence. These were, indeed, the first up-to-date Hungarian hybrids.

László Berzsenyi-Janosits was one of those who were not satisfied with merely producing new varieties, but endeavoured to make them of profit to the national economy, as production factors yielding a surplus value. (He was not responsible for the fact that the financial conditions required for basic stock production were not available for more than 10 years, and the actual improvement was only felt in the seventies.)

Perhaps the most fruitful activity of his long career was when acting as a reader or opponent, or when passing verbal judgement, in the course of which he offered invaluable help to beginners and more experienced researchers alike. He gave perspectives to the work of some of them, called their attention to useful up-to-date methods, and made others turn back from the wrong track to the right way towards their goals. All this he did in an unselfish way, standing on the firm ground of his vast knowledge and experience. He read all the most important books and papers written in the major western languages (English, French, German) and published resumés of them, which he also made use of in his own work. He was one of the first in Hungary to acquire a knowledge of modern biometric techniques, which he passed on to other researchers if they were prepared to listen.

He published the results of his wide-ranging research in 9 books (as author or co-author) and 60 papers. As a recognition of his scientific activity a C.Sc. degree in agricultural sciences was granted to him in 1952. The success of his creative work in plant breeding and research management was marked by the State Prize he was awarded in 1970; then in 1971 he became the holder of the Rudolf Fleischmann plaquette.

His retirement in 1969 did not mean the end of his active career. Right up to his death he took part in the maintenance of his maize hybrids and inbred lines. He continued to give reader's opinions and expert advice even on his sick-bed. His sense of vocation was proverbial.

With the death of László Berzsenyi-Janosits we have lost a great man who was devoted to his work and prepared to make any sacrifice in the interest of science. It was part of his character to take every tiny detail into consideration and to believe firmly in the classical principles of his profession, thus deriving the strength to come through the stormy period of his life victorious, with unshaken faith and with bright hopes for the future. His education and wide professional knowledge made him extremely particular about scientific questions. For many years he was an active member of the Plant Breeding Committee of the Hungarian Academy of Sciences. His personal presence and participation in the work were sufficient in themselves to guarantee a European standard.

When László Berzsenyi-Janosits left us he was the doyen of Hungarian plant breeders, yet he will be remembered as a colleague who was youthfully open to new ideas, who immediately grasped the essentials, an indefatigable worker born to make outstanding achievements, whose example imposes obligations on a whole series of generations.

J. NÉMETH

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RECENSIONES

WILCOX—VAN HORN: *Large Dairy Management.* University Press of Florida, Gainesville 1978.

This work, written by well-known authors mostly from North America, is of special importance in these days. It is almost a world-wide phenomenon that, particularly in countries with a developed form of dairy management, the number of cows on the dairy farms is increasing. A large stock is especially characteristic of dairy farms established in the socialist countries. The liquidation of small peasant farms is not the only cause; the high investment costs can only be reduced by an adequate concentration of stock, and the insufficient labour force can be much more rationally utilized on a large farm. It was partly due to these briefly outlined reasons that the editors compiled the material of the symposium held at Gainesville (Florida) in 1976. The symposium discussed the manifold problems of large-scale dairy farms. The thick volume, covering more than 1000 pages, pays special attention to subjects related with feeding, breeding, milking, sanitation, labour management and capital demands on large dairy farms. It is a well-known fact that in many respects large dairy farms encounter totally different problems than the traditional farmer who owns 20–50 cows, or the European medium-sized peasant farm. It is also common knowledge that in the United States of America the establishment of dairy farms keeping several hundreds of cows has a history stretching far back into the past. This is best proved by the fact that in most European countries the large-scale husbandry techniques, and for the last few decades even the breed (the USA-Canadian Holstein-Friesian cattle) have been introduced mainly from the United States. This technical advantage of the New World makes the book particularly instructive for European specialists, as we are closely interested in large-scale dairy management. Of all the European countries it is Hungary that has imported the largest number of Holstein-Friesian pure-bred animals (some 23 000 female cattle) from the United States and Canada, as a result of which Hungary possesses the largest pure-bred Holstein stock in Europe.

The authors, nearly 80 in number, who are almost without exception the best North American experts, discuss the different problems giving due consideration to the demands of large farms. The various chapters in the book deal in depth with biological and technical questions which are important for the management of dairy farms, and with the genetic background of economically important properties including resistance to diseases, sensitivity to stress, etc. In the chapter dealing with the problem of reproduction, not only general questions, but the problems of artificially induced heat, large-scale control of reproduction processes, induction of calving and hormonal induction of lactation are discussed.

The chapter on feeding deals in detail with the questions of trace elements and roughage supply, metabolic disorders, feeding of by-products and nutrition stress. Great attention is also paid to the problem of replacement, chiefly heifer rearing. Under the subject of sanitation emphasis is laid on the control of mastitis, a disease which affects large herds most severely, calf mortality and parasitoses. The application of computer techniques in large-scale registration and the grouping of animals by feeding regime are treated in a particularly up-to-date manner. A chapter covering some 100 pages deals with the questions of mechanization, housing, equipment, manure removal and the creation of a suitable environment. Finally, separate chapters discuss the questions of management, supervision, the supply and training of workers, and the problems of accounting, financing and planning; the latter are naturally based on American conditions.

The book will give a wide range of information to those engaged in the direction of management of large dairy farms, to those teaching at universities and colleges, and to all those professionally connected with large-

scale dairy farms either as consultants or on the industrial side. Scientific and practical knowledge is properly combined in all the chapters, so that not only researchers but practising farmers can profit from the book.

A. HORN

HULSE, J. H.—LAING, E. M.—PEARSON, O. E.: *Sorghum and the Millets; Their Composition and Nutritive Value.* Academic Press, London, New York, Toronto, Sydney, San Francisco 1980. 997 p.

The renowned Canadian authors from the International Development Research Centre, undertook a work of great scientific and practical importance when writing this monograph. On the basis of his precomprehend and evaluate the full meaning of growing grain sorghum and millets. And this is quite understandable, since in Europe these crops, grain sorghum in particular, serve almost exclusively as feed and even then only when the local soil and climatic conditions are not suitable for growing the somewhat more valuable maize. Under poor production conditions sorghum is a good substitute for maize, so it has been cultivated in Hungary, too, for some two centuries. On other continents grain sorghum and millets play a more important role in the public food supply. It is no exaggeration to say that these grain crops form the staple diet of the poorest peoples of the Earth. It is thus quite natural that plant breeders and growers make every effort to increase the yields and nutritive value. The authors of the book have also done their best to contribute in their own way to the achievement of this noble aim. They have processed more than 1700 original sources dealing with the description, chemical composition and nutritive value of these cereals, the conclusions drawn from these have then been enriched with their own research results and practical experience, and tables and figures have been added for easier comprehension. A detailed bibliography helps the readers (research workers, breeders and growers) in looking up sources which are considered important.

The book consists of 6 main parts. *Chapter One* is mainly concerned with the economic, cultivation and nutrition conditions of the semi-arid tropical zone of the Earth, in other words, those parts of the world where the production of grain sorghum and millets is of the greatest importance. The reader is then made acquainted with the methods used for nutrient analysis and with the major composition parameters of sorghum and millets.

The *Chapter Two* gives a comprehensive literary survey of the history of the sorghum and millet varieties grown in the world and of the major research results achieved. The tissue structure of sorghum and millet is presented, together with the location of the various nutrients within the seed. Besides the major chemical components information is given on the role and chemical composition of sorghum wax, the question of starch gelatinization, the pentosane and fibre content, the biological value of these grain crops and methods for evaluating it on rat, poultry, pig, cattle and sheep.

The *Chapter Three* deals with genetic questions concerning sorghum and millets: hybridization, the interaction between genetic and environmental factors, and cultivation problems. This chapter discusses genetic questions regarding the nutrition of high lysine mutants and the evaluation of induced mutants rich in lysine. The evaluation of production and environmental factors, and the methods and efficiency of manuring and fertilization in various countries are dealt with at considerable length.

In *Chapter Four* inhibitors and toxic substances which decrease the nutritive value are described. In fact there are many foods and feedstuffs, from potatoes to legumes, which contain large quantities of certain toxic materials, particularly saponines, but nevertheless make up an important part of the diet. The polyphenols, and their chemistry and development in the plant, are discussed in detail, and the reader is made acquainted with the relationship between tannin content and digestibility, and the harmful effect of tannin on man, poultry, pig and ruminants. Other anti-nutritive factors, such as phytic acid and cyanogenic glycosides, are also presented in this chapter, with a description of the consequences of consuming toxic compounds: e.g. disturbances in the amino acid balance, pellagra, fluorosis and urolythiasis. The authors touch on the question of toxic factors which are unknown as yet, on the presence, causes, varieties and quantities of mycotoxins, and on the problem of possible insect infestation.

The subject of *Chapter Five* is the handling and processing of sorghum and millet seeds and their preparation for human consumption. The various industrial and laboratory milling techniques, the grading of the milling product and the method of starch extraction are dealt with in detail. The production of bakery goods and pastas sorghum and millet flour, malting, brewing, and sorghum wine making are also important subjects of this chapter. The authors also discuss certain questions of preparing and using sorghum and millets for feeding purposes. Spaking,

steaming, flaking, extrusion, popping and micronization are primarily worth mentioning.

In *Chapter Six* sorghum and millets are compared with other food and feed grains. Particular interest may be aroused by one of the literary sources, in which the Earth is divided into zones and countries according to whether they produce and utilize mainly: *a)* animal protein, *b)* wheat, *c)* sorghum and millet, *d)* maize, *e)* mixed grain crops, *f)* rice or finally *g)* root and tuber crops, vegetables and green fodder. The authors compare the crop yield and protein yield of sorghum and millets to those of legumes, cereals, oil plants and other crops with high protein contents, and also to feeds of animal origin, microbic protein products, synthetic amino acids, etc. Their influence on human and animal organisms and on products of animal origin, and their dietetic effects are also compared.

The tables (514 in all, many of which cover several pages) are placed at the end of the book. Although, this makes the reader's work somewhat difficult, it is nevertheless a wise solution, since the unusually large number of tables would make the content less clear if they were placed within the text.

In the appendix two botanical vocabularies are found in alphabetic order, the first of which gives the scientific synonyms of common plant names, and the other the common equivalent of the scientific plant names mentioned in the book.

The book is not easy reading. It is a monograph of documentative character, where the documentation takes priority over monograph. It would have been more to the purpose to leave out the large number of references to the sources, and write the book in a more readable form. In this way the authors could have given the readers more for less effort. Readers from European countries, and from developed countries in general, including Hungary, would prefer to have more information on the management and economic aspects of livestock farming, even at the expense of the human aspects.

This valuable publication is recommended primarily to breeders, as well as to researchers interested in the problems of plant production and feeding.

I. HEROLD

Vedecké práce 26, Rada E. 1979 Statni Pedagogické Nakladatelstvi v Praze, 235.
(Scientific Bulletin No. 26, Rada E. 1979. State Pedagogical Publishing House, Prague, 235.)

Reading through this year-book I was reminded of a basic criterion that should be the cornerstone for any applied research institution: to keep abreast of current practical problems. It was not by chance that this thought entered my mind; the year-book gives evidence of the fact that the agricultural economists of this college are fully aware of this requirement. They see beyond the confines of their studies and respond to the events they see outside with the aid of thorough economic, legal, financial and managerial analyses.

In agriculture, as in other fields of economic life, the socialist farms are undergoing a process of intensive concentration. This has been achieved in various forms from specialization to co-operation and integration. The most developed form of integration is various horizontal and vertical types of integration between agriculture and the food industry. The advantages of these changes are generally well known, but compared to the previous economic and legal conditions different systems will have to be elaborated under the new circumstances, e.g. in creating financial resources, in laying down the principles of various kinds of remuneraton and even in the distribution of profit.

The above problems are dealt with in the papers "Income distribution in co-operation" by HURTA, "Economic problems of integration in an agricultural and food industry complex" by MACH, and "Developments in the legal regulation of co-operation in Czechoslovakian agriculture" by VOKATY. In VOKATY's work the legal questions of subsidiary enterprises are also discussed.

In the paper "The dispatcher system of management, its bases and structure in agricultural production" PECHAC and HAVRANEK offer assistance in directing the work of agricultural enterprises, production systems or agricultural districts. The basic task of the dispatcher system is the continuous operative, complex management of the farm units according to a given plan, and is connected with the following groups of activities: planning, organization and co-ordination, information, decision-making, supervision, management servicing and other general auxiliary activities.

A theoretical paper by HRON contributes to the planning of organization systems for the agricultural enterprises of the future. The author illustrates why the number of management levels should be reduced, and suggests working out a management structure on the basis of the "construction principle" elaborated by JOHAN VON NEUMANN.

It would be difficult to give priority to any one paper. Among others the papers "Theoretical bases for establishing organizational norms in agricultural enterprises" by KEIL, or "Terminological and conceptual sys-

tems" by DROZD could lay equal claim to this. A very interesting attempt is made by PECHACOVA in the paper "Professiographic analysis of management work": while this method fails to demonstrate any significant difference between "successful" and "unsuccessful" managers on the basis of the questions raised, it offers a new approach to the question, which is worth following up, if only because of the timeliness of the subject.

English, German and Russian summaries are to be found at the end of each paper. The year-book is warmy recommended to those engaged in the theory and practice of agricultural economics, as well as to the managers of farms and agricultural enterprises who are searching for the paths of the future in this field, as they will find useful assistance in the ideas and propositions raised by the research workers at the Faculty of Agricultural Economics of the Agricultural College of Prague.

Z. BEDŐ

J. MACMILLAN: *Hormonal Regulation of Development I. Molecular Aspects of Plant Hormones* (Encyclopedia of Plant Physiology, New Series, Volume 9), Springer-Verlag, Berlin, Heidelberg, New York 1980.

This book is the first in a set of three volumes in the Encyclopedia of Plant Physiology (New Series) that will cover the area of hormonal regulation of plant growth and development. This volume deals with the molecular and subcellular aspects of plant hormones and the processes they regulate. As is mentioned in the foreword of this book, the second volume will discuss the role of hormones at levels of organization from the cell up to the plant, while the third volume will deal with the interrelationships of hormones with factors in the environment of the organs and whole plants within which the hormones are functioning.

The book is unique in that, among the books which have been published on plant hormones until quite recently, it is the first to discuss the five groups of hormones on the basis of their common properties. Therefore, it differs from the traditional method in which each group of hormones was discussed separately. The six chapters in this book are organized according to the new system, involving every important topic in this field. Thus, it deals in detail with the occurrence and chemical structure of plant hormones, and with their biosynthesis and further metabolism; it also describes techniques used for the extraction, purification, qualitative and quantitative analysis of each hormone, and reviews the molecular and subcellular aspects of their action and the molecular effects of hormone treatment on tissues.

The most significant characteristic of the book is that the data are presented very clearly, tabulated where necessary, so that the information needed can easily be found. The book reviews a great number of references which were published prior to the date of editing, and in addition, in the introduction to the book, written by the editor, Professor MACMILLAN, there is a brief addendum to each chapter noting results which were not discussed in the book, having been published too late or being still in press when the book was edited. Thus, the book is almost certainly the best comprehensive text on growth and development regulators, i.e. plant hormones, and merits a place in every scientific library.

The first chapter, entitled "Plant Hormones and Other Growth Substances — Their Background, Structure and Occurrence", is written by BEARDER. It deals with the five groups of plant hormones, namely: ethylene, auxins, gibberellins, cytokinins, and abscisic acid and related compounds. In each case the author gives a brief historical background of the discovery of plant hormones. Data on their chemical structure and occurrence in different plant organs, with the titles of references which have been published on the topic, are tabulated, except for the description of ethylene, and are thus very clearly arranged. For instance, besides free auxin (indole-3-acetic acid, i.e. IAA) there are many other indole derivatives in plant organs, such as indole-3-acetyl, indole-3-acetonitrile and other indole compounds, e.g. chloroindoles, which also affect plant growth regulation. Up till now, fifty-seven types of gibberellin and seventeen cytokinin compounds have been identified in different plant organs.

This chapter also gives a summary of other plant constituents which affect plant growth and development, including aromatic, nitrogen-containing, terpenoid, aliphatic and other compounds.

The second chapter, entitled "Extraction, Purification and Identification", is written by YOKOTA, MUROFUSHY and TAKANASHI. In this chapter both classic and recent methods developed for the extraction, purification and identification of plant hormones are described. In the first section of the chapter some good advice, which should be taken into consideration in qualitative analyses, is given both generally and specifically. Thus, the reader can find descriptions of methods for the extraction of active principles from plant material, of a fractionation procedure based on solvent partitioning and ion exchange resin, and of the application of

various types of column chromatography, such as adsorption column chromatography, sephadex column and gel permeation column chromatography and insoluble polyvinylpyrrolide column chromatography.

Some examples of the purification of plant hormones are also presented. Several techniques which have already been applied in this field are described in detail. For example, procedures for isolating auxins from young citrus fruits, gibberellins A_1, A_5, A_6 and A_8 from immature Phaseolus seeds, cytokinins from immature sweet corn, abscisic acid from young cotton fruits, etc. are mentioned. Thus, the most suitable procedure for investigating any of these hormones can be chosen.

The second part of this chapter deals with identification techniques which do not involve isolation. Firstly it outlines the basic criteria for identification and reliability, then summarizes methods which have been used for identification, such as paper and thin-layer chromatography, gas-liquid chromatography, high performance liquid chromatography, combined gas-liquid chromatography and mass spectrometry, and a method in which optical rotatory dispersion and circular dichroism are utilized for the determination of abscisic acid only.

The third chapter, entitled "Quantitative Analysis of Plant Hormones", is written by REEVE and CROZIER. The endogenous plant hormone level can be estimated by an analysis of the solvent extracts of plant tissues. In these tissues, however, many other compounds are also present, which may disturb the precision of the method used for the investigation. Therefore, a statistical analysis is required by which the true value of the hormone level can be obtained. The first section of this chapter summarizes data on statistical analysis used for the quantitative estimation of plant hormones. Two approaches to the problem are presented. One deals with basic analytical errors, accuracy and precision, and the other with the analysis of samples from open-ended systems.

The other sections in this chapter describe methods by which the individual hormone level can be determined. For instance, bioassays which have been used for many years as a means of analysing the hormone content of plant extracts are reviewed. Different types of auxin, cytokinin, gibberellin and abscisic acid bioassays are presented in tables, including the minimum detectable hormone level and the range of linear response to individual hormones. Recently, immunological assays, which were earlier used in the field of mammalian endocrinology, have also been applied in plant hormone analysis, so in this chapter there is a brief summary of the use of this technique in plant hormone assays. Furthermore, ways of using physico-chemical detectors in hormonal investigations are also presented, including the information necessary for their application.

Seeing that chromatographic procedures are very often used in the analysis of endogenous hormones, it is important to know the maximum number of components that can be simultaneously separated from each other. Some statistical information concerning this problem is presented, together with internal standards which may influence the accuracy of quantitative estimates. Finally, analytical procedures suitable for hormone characterization in plant extracts are also presented.

The fourth chapter, entitled "Biosynthesis and Metabolism of Plant Hormones", is written by SEMBDNER, GROSS, LIEBISH and SCHNEIDER. A great number of experiments concerning the biosynthetic pathways of individual hormones and their further metabolism in plants have been carried out up to the present date. The chapter is divided into two parts, one of which describes the biosynthesis of each hormone, while the other outlines the hormone metabolism, including interconversion and catabolism.

Having read the description of the biosynthetic pathways, the reader is in possession of the following information. In the biosynthesis of auxins the protein amino acid, L-tryptophan, is suggested as being the primary precursor. This is supported by the close chemical similarity between tryptophan and IAA and their ubiquitous occurrence as natural constituents of higher plants. The conversion from tryptophan into IAA may proceed, via different pathways, such as the indole-3-pyruvic acid, tryptamine, indole-3-acetaldoxime pathways, etc.

The biosynthesis of cytokinins is closely related to the metabolism of RNA, especially of tRNA, because both cytokinins and RNA have an adenine moiety; they both originate from the same purine pool; cytokinins have been shown to exist in nature as the base, the ribonucleoside and the ribonucleotide; and tRNAs have been proved to contain active cytokinins and cytokinin-like adenine derivatives which are always situated at the important position adjacent to the anticodon triplet. The authors present a description of the biosynthesis of both tRNA-cytokinins and free cytokinins.

Two plant hormones—abscisic acid and gibberellin—are of terpenoid origin; it has been demonstrated that abscisic acid belongs to the group of sesquiterpenes, and gibberellin to the diterpenes. Consequently, the biosynthesis of these hormones is connected with terpene formation, in which process mevalonic acid has been shown to be the specific precursor. Fig. 4.3 presents the biosynthesis of

sesquiterpenes and diterpenes from mevalonate in general, which leads to the biosynthesis of abscisic acid and gibberellins. The detailed biosynthesis of these two hormones is also described.

Concerning the study of ethylene biosynthesis, firstly a brief summary is given on ethylene formation in a model system in which methionine and linolenic acid play the role of precursors, then the synthesis in vivo, i.e. the physiological pathways, are discussed, demonstrating the fact that ethylene is derived from methionine in higher plants.

The second part of this chapter outlines the hormone metabolism individually. Our present knowledge of the auxin metabolism is restricted to the catabolism of IAA. A great number of scientific articles have been published in this field. The IAA catabolism may proceed both enzymatically (by peroxidase, IAA-oxidase) and non-enzymatically (by acids, ionizing radiation, ultra violet light, visible light, etc.). The most important pathway is oxidative degradation, which is clearly presented in Figs 4.22 and 4.23. The IAA metabolism has great significance in controlling the endogenous auxin level, which is important from the viewpoint of regulating different physiological processes such as cell growth and differentiation, fruit ripening, senescence, apical dominance, etc.

In the metabolism of cytokinins some new compounds are formed by interconversion, degradation or conjugation. Since cytokinins occur in plants both in their free state and incorporated into tRNA, their metabolism shows some peculiarities in comparison to the metabolism of other hormones. Results published on the metabolism of natural cytokinins are summarized in Fig. 4.25.

Concerning the abscisic acid metabolism two different pathways have been suggested. The first is via conjugation with glucose to form the ester glucoside, the second is via oxidation, leading to metabolites possessing only very low or no physiological activity.

The gibberellin metabolism proceeds by interconversion (dehydrogenation, hydroxylation, which is the most common, or transformation) and by catabolism. In most cases metabolic experiments with labelled gibberellins lead to the formation of unknown radioactive compounds which may represent degradative reactions. Catabolic routes seem to occur as a means of reducing the biological activity of gibberellin.

Plant hormones, as has been demonstrated in a large number of scientific works, occur in plants not only in the free form; usually they are metabolically bound to other low molecular weight compounds (amino acid, sugar, etc.) by covalent bonds. These types of complexes are called hormone conjugates, as opposed to bound hormones, which are hormone-macromolecule complexes. The hormone conjugates have a specific role in the regulation of plant growth and development, so a brief summary of them is presented.

The last section of this chapter offers some information on the localization of the biosynthesis and metabolism of hormones.

The fifth chapter, entitled "Molecular and Subcellular Aspects of Hormone Action", is written by STODDART and VENIS. Hormones in general exert physiological or biochemical effects that are specific to their particular class. The active molecules must be recognized by the cell and distinguished in some way from other compounds. Probably, specific hormone-binding proteins fulfil this function in the living organism. Thus, certain minimal criteria which should be satisfied in binding the hormone to the macromolecule are presented by the authors, followed by a brief report on the general methodology of receptor studies.

Data concerning molecular and subcellular hormone actions are discussed separately for each hormone, and there is a review of different theories which have been published in connection with the structure-activity relationships of hormones, including a description of hormone analogues and the structural requirement for activity. It has been demonstrated that plant cells contain specific recognition sites (receptors) for the individual hormones. In spite of the fact that a great number of scientific papers have been published on research carried out on the molecular and subcellular aspects of hormone action, this subject has not been discussed satisfactorily even in the case of auxins, which have been investigated in the greatest detail.

The sixth chapter, entitled "Molecular Effects of Hormone Treatment on Tissues", is written by ZERONY and HALL. In studying the mode of action of plant hormones the most common method is the exogenous application of such substances to plant tissues. The method is based on the idea of replacing the endogenous, naturally occurring hormone by an exogenous hormone, the level of which may be controlled and its effect monitored. Of course, there are certain internal factors in plant tissues which may influence the true effect of exogenous hormonal application, as is pointed out in the introduction to this chapter; however, this method has great importance in hormone research.

In the last two decades a great number of papers have been presented on the effect of hormones on processes involved in plant growth and development, but there is nevertheless some contradiction between the results. The chapter gives a summary of scientific works in this field. It provides data

on the effects of auxin on cell extensibility, showing the fact that auxins influence the kinetics of growth processes, nucleic acids and protein synthesis in elongating tissues, the pH value of these tissues and the metabolism of the cell wall. Although the effects of other growth regulators on cell extension have been studied in a number of systems, very little information is available concerning the problem. As is outlined in this chapter, growth regulators also affect the ion transport and regulate membrane properties. It has been demonstrated that auxins control a mechanism involving changes in the transport and metabolism of cell wall constituents. The effect of growth regulators on the mobilization of food reserves in seeds has also been proved. Finally, some results are presented on the effects of hormones on differentiating systems.

I. KOVÁCS

E. HANSEN, V. ISRAELSEN, E. STRINGHAM: *Irrigation Principles and Practices.* John Wiley and Sons, New York, Chichester, Brisbane, Toronto, Fourth edition.

I

This year the excellent work of HANSEN—ISRAELSEN—STRINGHAM "Irrigation Principles and Practices" has run into its fourth edition.

Some of the Hungarian irrigation experts have even been acquainted with the second and third editions published in 1950 and 1962, respectively. These editions reflected mainly the conception of ORSON V. ISRAELSEN as regards content, structure and form alike. The American professor known in scientific circles all over the world was born in 1887 and died in 1968. The recently published fourth edition is dedicated to him.

This edition—like the former ones—is characterized by an effort to keep to the essentials. Its well-proportioned structure and clear style are special advantages for readers with native languages other than English.

Since the appearance of the third edition the theoretical and practical research of irrigation has yielded new results. Irrigation areas have substantially grown all over the world, and new practical experiences have accumulated. To draw general conclusions from all this and show the most important practical methods it was necessary to revise the third (1962) edition.

In my opinion the authors have accomplished a thorough modernization of the content while retaining the mentioned useful and valuable features of the previous editions.

Their work is in the first place a concentration of American experiences. Also, it is mainly there that their methods can be introduced in general practice.

However, the presented—mainly ecological and technical—principles of irrigation development, and a considerable proportion of the practices are of global validity. Most of the principles and many practical solutions may be instructive and well adaptable to actual natural and social conditions irrespective of country or continent borders in any place where the necessity of irrigation has arisen or will arise. A large part of them tally with results and experiences obtained in Hungary.

The book shows the development of irrigation in the world, its problems from sources of water to gutters. It discusses the technical questions of water resources, -storage, hydrometry, lifting and transporting of water.

The major principles of relations and interactions between soil-water-climate-plant on the one hand, and irrigation on the other are above all of general validity. Great importance is attached to the characterization of salty and alkali soils and waters, and to the rules to be kept in using water.

The authors present tables and methods to answer the fundamental practical question of "how to irrigate and how much water to use for irrigation".

The book also discusses the legal, administrative and social questions related with irrigation from various sides. The information supplied by these passages on the nature of the system of relations between irrigation and society though not directly applicable may be of indirect use for the Hungarian readers.

Mention must be made of two useful supplements to the structure of the book. Beside the SI measurement system generally used the English units (tables, equations and figures) which might be required for the application or comparison of the English system are given in appendix.

As another practical supplement the content of each chapter formulated in a brief sentence is found at the end of the book under the title "Problems and questions". This helps in getting a hold of the information supplied and increases the possibility of making use of the book in university education and extension work.

II

The book "Irrigation Principles and Practices" is divided into 17 chapters on a total of 417 pages.

The first chapter begins with the short history of irrigation and the definition of the concept of irrigation.

According to the data on the irrigation areas of the world in 1974—the last year covered by the book—there were 26 countries where the irrigation area exceeded 1 million ha, and the total area irrigated in the world was 233.6 million ha.

Chapter II deals with the resources of irrigation water and the different types of reservoir. Surface and groundwater storage are discussed separately.

Chapter III acquaints the reader with the general concepts and rules of soil-water relation, giving information about the texture and structure of soil, the forms of moisture, the tension of water and soil moisture.

The only subject of Chapter IV is hydrometry, including sample taking, and the gravimetric, porose block, tensiometric and neutron measuring methods.

Chapter V outlines the phenomenon and theoretical bases of water movement in the soil and the different ways of measuring it. Of these seeping during irrigation and data concerning the movement of groundwater are closest to the practice of irrigation. Attention should be called to the statement concerning the limits of applying equations for various forms of water movement in practice.

Salt problems of soil and water are dealt with in Chapter VI. After several definitions and chemical correlations the authors make the possibilities of intervention concerning the improvement of soil and water known.

Besides information about the deterioration of the quality of irrigation water the book dwells at some length on the problem of salt tolerance by plants, discussing within this scope the effect of the salt content of soil on the nutrition of plants.

The theoretical and practical questions of the use of water are summed up in Chapter VII. After some conceptual definitions the direct methods of measuring and calculating the volume of water utilized are outlined. Of the latter only the following four are described: the modified Penmann, the Jensen-Haire, the Hargreaves and the modified Planey equations.

A tabulated summary is given of the relative water consumption of 27 plant species during vegetation.

Chapter VIII gives detailed answers to the question of "how to irrigate, and how much water to use for irrigation". It mentions winter and early irrigation, rates and frequency of irrigation. As perhaps the most instructive feature of the chapter the degree of efficiency of irrigation (water) and its utilization are analysed in detail. Within this the conveyance, distribution and storage of water are discussed separately. With the view of an economic use of irrigation water increased attention should be paid to these processes in Hungary too.

Chapter IX contains a comparison of the sprinkling and trickling methods of irrigation. A fairly detailed account is given of sprinklers and sprinkling irrigation systems. The description of the trickling irrigation is relatively short, and little is spoken of the achievements of the last 1–2 years.

In Chapter X the questions of surface and subsoil irrigation are summed up which do not say much that is new to the Hungarian readers.

Chapter XI deals with the instruments and equipment of irrigation, first of all with the machines of ground levelling, canal construction, with the typifying of various structures and with the instruments of water conveyance. Of the latter the portable aluminium canal e.g. is not known in Hungary.

Chapter XII presents the hydraulic principles of irrigation water conveyance (Darcy, Chezy, etc.), and gives a survey of the methods and materials of constructing permanent canals.

Chapter XIII discusses the problems of irrigating from wells, and makes the readers acquainted with the hydraulic questions of wells required for obtaining irrigation water, and with the various methods of making wells.

Chapter XIV gives a survey of the development of lifting and pumping irrigation and drainage water. A special section of the chapter is devoted to the energy and cost structure of the different pump systems and their size order.

Chapter XV summarizes the drainage problems of irrigated areas, the hydraulic and organization questions of constructing and operating open and closed (underground) drainage systems.

In Chapter XVI emphasis is laid on the volume of water used for irrigation. The economic and efficient use of irrigation water postulates the knowledge of the extracted, conveyed and distributed volumes of water. With this in view the book presents several excellent methods.

Chapter XVII contains the legal and administrative aspects of irrigation and water management.

As a conclusion some evaluative comments can be made.

The fourth edition of the book "Irrigation Principles and Practices" is first of all a high level summarization of American experiences of irrigation. The recently published fourth edition retains Prof. ORSON V. ISRAELSEN's original conception when discussion the practical methods and problems of irrigation as not separated from the presentation of general principles and theoretical bases.

The multifactorial natural-technical and socio-economic questions of irrigation are summed up in a clear structure, with the essential problems and interactions emphasized, giving a comprehensive view generally on the level of the latest pieces of information.

It is mainly for active irrigation engineers that the book outlines the most important theoretical and practical questions of irrigation. Without such a knowledge the development of irrigation is unfeasible under the increasingly complex ecological, technical and economic conditions, not only in America but in most countries of the world as well. Some of the Hungarian experts will be confirmed in many questions, while others might be encouraged to step forward.

I. PETRASOVITS

Nucleic Acids and Proteins in Plants. Encyclopedia of Plant Physiology, New Series Vol. 14A. D. BOULTER and B. PARTHIER Eds. Springer-Verlag, Berlin, Heidelberg, New York 1982. pp. XV + 768.

The first volume of "Nucleic Acids and Proteins in Plants" contains contributions from 24 authors. The approach is "encyclopedic", i.e. the authors have mostly provided a solid background which is based on a detailed account of well established facts, but they have also tried to make the information as up-to-date as possible. The material is divided into two sections: I. General aspects of protein biosynthesis and metabolism in plants and II. Processes specific to plant physiology. Section I contains 13 chapters and Section II five.

Aptly, Section I is introduced by a chapter on "Ammonia assimilation and amino acid metabolism" by B. J. MIFLIN and P. J. LEA. This chapter gives an up-to-date account of the flow of carbon during the synthesis of the major amino acid families, and also describes the main features of amino acid catabolism. The second chapter is by J. H. WEIL and B. PARTHIER on "Transfer RNA and aminoacyl-tRNA synthetases in plants". Stress is laid on the methodological aspects, structural peculiarities, subcellular distribution of plant tRNAs, tRNA genes and tRNA function. The aminoacyl-tRNA synthetases are dealt with from similar points of view. A fairly concise chapter on "Ribosomes, polysomes and the translation process" is written by A. MARCUS. Much more detailed is a chapter by L. BEEVERS on the "Post-translational modifications" of proteins. To the knowledge of the reviewer, this is the first attempt to summarize the post-translational modifications in plant proteins. This chapter definitely fills a gap. Ph. Matile's contribution, "Protein degradation", deals with protein degradation in germinating seeds, leaves and in yeast cells as model systems. The "Physiological aspects of protein turnover" are discussed by D. D. DAVIES. The critical treatment of the methodological problems involved in any work dealing with protein turnover is the most valuable feature of this chapter. J. A. M. RAMSHAW wrote one of the unique chapters of the book: "Structures of plant proteins", the first approach of its kind, which tries to give an overall picture specifically on plant protein structure. Another original approach is the very detailed chapter by M.-N. MIÈGE on "Protein types and distribution" within the plant. P. I. PAYNE and A. P. RHODES summarized our knowledge on "Cereal storage proteins: structure and role in agriculture and food technology". R. C. HUFFAKER wrote a chapter on the "Biochemistry and physiology of leaf proteins". The title is somewhat misleading. Actually selected leaf proteins are dealt with (e.g. ribulose bisphosphate carboxylase, nitrate reductase, nitrite reductase, etc.). D. D. SABNIS and J. W. HART gave an up-to-date summary of "Microtubule proteins and P-proteins". A field rarely surveyed is that dealt with by C. F. HIGGINS and J. W. PAYNE: "Plant peptides". It includes such heterogeneous topics as the physiological role of glutathione, the peptide hormones and the role of the peptides in plant pathology. "Immunology", a chapter written by R. MANTEUFFEL, deals with lectins, protease inhibitors, phytochrome, leghaemoglobin, storage proteins and incompatibility reactions. It is a somewhat arbitrary collection of loosely related, albeit interesting material.

In Section II, "Seed development", written by K. MÜNTZ, is the first detailed account of this topic to make full use of the spectacular results of molecular biology in this field. "Protein and nucleic acid synthesis during seed germination and early seedling growth" was discussed by J. D. BEWLEY. J. L. STODDART and H. THOMAS wrote a review on "Leaf senescence". This phenomenon is treated as a developmental event. The last chapter in the book is that written by D. H. NORTHCOTE on "Macromolecular aspects of cell wall differentiation". The Editors and the Publishers must be congratulated, because they have succeeded in incorporating so much original material into the volume that it has not become "yet another" up-to-date book on plant proteins, but represents an "oeuvre" irreplaceable by other sources. Author index, plant name index and subject index render the book an invaluable source of reference for all plant physiologists and research workers dealing with related areas.

G. L. FARKAS

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